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Science Experiences Of Six Elementary Student Teachers: A Case Study

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SCIENCE EXPERIENCES OF SIX ELEMENTARY STUDENT TEACHERS:

A CASE STUDY

by

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This dissertation, submitted by Jacqueline K. Wilcox in partial fulfillment of the requirements for the Degree of Doctor of Philosophy from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

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ABSTRACT

This qualitative study focused on the science experiences of six elementary student teachers. The purpose of the study was to learn how preservice teachers make meaning of science teaching during their student teaching experience. The sources of data were interviews with participants, descriptive field notes from observations of their science teaching, and artifacts collected from the site. The themes that emerged from data analysis were personal and professional career influences and constant adjustments of teaching strategies. The participants experienced these themes in varying intensities.

Learning to teach science to elementary children for the first time is complicated by the context of student teaching. The science teaching experiences of student teachers varied with the cooperating teachers' approaches to science teaching, the lengths of time they were assigned to teach science, and the science schedules of the classroom. The role played by mentors interested in science can be important in a student teacher's science experience. Images of science teaching held by student teachers were also found to influence the science teaching experience.

The science curriculum, group management skills, and student responses affected the science teaching experience, as did personal knowledge of a science topic being taught. Those student teachers who had limited knowledge of a science topic became factually oriented in their teaching and tried fewer teaching approaches. Lack of experience and management skills with cooperative groups hindered student teachers' use of hands on activities. Affective student responses to their science lessons were

important to some of the student teachers, while others were concerned about student questions and cognitive learning.

Upon completion of the student teaching experience, four of the participants ranked science third or lower in a rank order of subjects they enjoyed teaching during student teaching. At the end of their student teaching experience, three of the student teachers were eager to teach science in their own classrooms and had a vision of how they would do so, but the other three were not sure how they would teach science.

CHAPTER II

REVIEW OF LITERATURE

The review of literature for this study addresses several topics related to the teaching of science in the elementary school and the development of preservice teachers especially during the student teaching experience. The first section provides the reader with a look at science in the elementary school and the science background of elementary teachers. The second section presents what is known about the science background of preservice elementary teachers. The third section discusses the beliefs and images preservice teachers hold about teaching prior to and during the student teaching experience. The components of student teaching are examined in the fourth section. The fifth section reports on science teaching during student teaching. Constraints towards science teaching are discussed in the last section.

Science in the Elementary Classroom

Elementary school teachers teach several subjects throughout the school day (reading, mathematics, writing, social studies, science, and spelling) in addition to the other agendas that crowd into the curriculum. Elementary teachers are expected not only to understand multiple subjects but know how to teach them. The content of the elementary school curriculum is not trivial. Many fundamental concepts are taught which lead students to higher order thinking (Stoddart, Connell, Stofflett, & Peck, 1993).

Teachers do not give equal time to every subject area. Different theories have been advanced to explain the inequities of time spent on different subject areas in elementary classrooms. Wenner (1992) believed that teachers devote more time to instruction in the areas that they like to teach. Hammrich and Armstrong (1996) advocated that teachers' world views influence their choice of what subjects are relevant and should be emphasized in the classroom. Raizen and Michelsohn (1994) and Trumbull, (1990) contended that school culture may also dictate which subjects are given priority in the elementary curriculum. Grossman (1989) believed that the relative subject knowledge level of teachers influences the time they devote to a subject. Weiss (1994) reported that teachers do not feel equally well qualified to teach all subjects in the elementary curriculum.

Researchers have painted a dismal picture of the extent of elementary science teaching over the years. One theme recurrent in the literature is that science is a low priority in most elementary classrooms (Raizen & Michelsohn, 1994; Weiss, 1994; Wenner, 1992), a phenomenon that began when science was first introduced into the elementary curriculum (Bybee & DeBoer, 1994). Wenner (1992) stated that science is often ranked the lowest by elementary teachers asked to prioritize by importance the subjects taught. Mechling, Stedman, and Donnellan (1982) and Westerback (1984) reported that over half of elementary teachers rank science fourth or fifth out of five subjects. Sherwood and Westerback (1983) cited national data that indicated elementary teachers spend less time teaching science than any other subject. Weiss's (1994) latest study discovered that science instructional time has increased slightly over the last 15 years, with an average of about one-half hour per day now being spent on science instruction. Raizen and Michelsohn (1994) found reading and basic arithmetic skills to be the dominant curriculum focus areas in the elementary school, with approximately 75 minutes a day devoted to reading and 50 minutes to mathematics. The 1990 National Assessment of Educational Progress (Jones, Mullis, Raizen, Weiss, & Weston, 1992) reported reading as the priority focus of the curriculum in 95% of the schools they surveyed. NAEP also found that 49% of fourth graders did not have science daily and that 6% never had science instruction. Schoenberger and Russell (1986) alleged that science is considered "a little added frill" rather than a basic curriculum subject in many classrooms, resulting in teachers integrating science with other subjects, teaching it infrequently, or ignoring it altogether.

For many years, researchers have reported that elementary teachers believe their inadequate science background is an obstacle to teaching science (Hove, 1970; Tilgner, 1990; Watson & James, 1997). Watson and James (1997) and Jones and Levin (1994) identified the lack of teacher background in science as the primary problem in the teaching of science at the elementary level. Mulholland and Wallace (1996) believed that a lack of science background is connected to a reluctance to actually teach science. Trumbull (1990) contended that many teachers have fears about teaching science because they feel they are not experts and will give students the wrong information. Trumbull also felt that good teachers who believe they have insufficient background in science might avoid science teaching, use science as a time to let students work on fun activities, or become authoritarian in their teaching of science. Arons (1983) believed, as a result of his study, that many elementary teachers' understanding of science is not much different than that of their students. Jones and Levin (1994) found that inservice elementary teachers who had taken three or more college science courses were more likely to give science a priority in their classrooms than inservice teachers who had completed only one science course in college. Wallace and Louden (1992) alleged that most elementary teachers lack scientific information, content knowledge in science, and the pedagogical knowledge for teaching science because the science courses they have taken typically emphasized detailed knowledge of specialized abstract cycles, formulas, structures, and principles. Roth (1989) argued that teachers' lack of the fundamental understanding of cycles and scientific principles makes it difficult for them to explain everyday phenomena in children's lives such as how plants get their food, why we eat, why it snows, or why bicycles rust.

Several studies have been conducted which focus on teachers' understandings and alternative conceptions of scientific concepts (Lawrenz, 1986; Smith, 1987; Waldersee Mintzes, & Novak, 1994). A Physical Science Test (PST) was developed and used by Lawrenz (1986) to assess the existing state of knowledge about physical science of more than 300 elementary teachers in a science inservice program. More than 50% were able to respond correctly to questions about atomic structure, off-center balancing, averaging, lenses, batteries, density, stars, heat exchange, and chemical reactions. Less than 50% could respond correctly to questions about mass, motion as related to collisions, electromagnetic phenomena, electricity, and light. He concluded that the teachers had either misunderstandings, no understandings, or were confused about the latter concepts. Smith (1987) interviewed ten elementary teachers before and after a four-week workshop on light and shadows. At the beginning of the workshop, the teachers lacked the general concept of light traveling in all directions from a source and were unable to provide satisfactory explanations of shadows, colors, and refraction; but by the end, they were beginning to replace their previous conceptions of light. Heller (1987) reported on elementary teachers' conceptions of electric circuits. She discovered that the elementary teachers held the misconception that energy flows from the battery to the empty conductors. She found that this concept is reinforced in most elementary science books, the principal source of basic science information for many teachers.

The knowledge oriented elementary science model that began in the late 19th century has continued into the present time (Bybee & DeBoer, 1994). Science teaching in the elementary classroom is typically textbook based (Weiss, 1994) and characterized by teacher talk (Roth, 1989). Student acquisition of facts is emphasized in science teaching (Raizen & Michelsohn, 1994). The content of the elementary science curriculum is defined to a large extent by textbooks and the questions asked in tests and examinations (Tobin, Briscoe, & Holman, 1990). Over half of elementary teachers cover 75% of the textbook. Teachers often perceive that parents and administrators expect students to cover the factual information in the textbook so they will do well on standardized tests (Cronin-Jones, 1991). Some teachers spend time teaching to the testing cycle or covering the science material so they can produce science scores or grades rather than practicing science the way they might prefer (Okegukola & Jegede, 1992).

Weiss's (1994) data collected from elementary teachers show that one out of two elementary science classes gives heavy emphasis to learning important terms and facts in science. Weiss also discovered that the largest proportion of class time is devoted to lecture/discussion (38%) but other methods of instruction are also used during class time:

hands on/laboratory work (23%) individual seatwork (19%) and non-laboratory small group work (10%) with the remaining 10% of time spent on daily routines and other non-instructional activities. Small groups are now being utilized for science instruction by the majority of elementary classrooms at least once a week, and roughly one-fourth of elementary classrooms use groups on a daily basis. Media is also used as part of classroom instruction. Videotape players are used in nine out of ten science classes and around one-half of elementary science classes watch television programs as part of their instruction.

Roth (1989), in a review of elementary science texts, found the majority to be generally organized around discrete topics as fossils, plants, rocks, weather, electricity, ecology, magnets, or rocks. Seven to nine topics representing the major science disciplines of earth, life, and physical science were presented at each grade level. Explanations of phenomena were presented briefly. Hands on activities that focus on observation and description of phenomena already described in the text were integrated in each unit as optional activities. The activities were presented as isolated experiences that were interesting, fun, and easy to do, without developing conceptual understanding of the science concepts covered in the unit.

In an observational study of fifth-grade science teaching, Roth, Anderson, & Smith (1983) found that the pattern of teaching in the text-based science classrooms consisted of oral reading of the text followed by answering of predominately factual questions. Teachers posed questions and listened to students' answers until the right answers were given. Hands on activities and teacher demonstrations were added to foster motivations but were often selected because they were easy to do or fun rather than for their usefulness in developing conceptual understanding. Teachers presented them as recipes, busy work, art processes, or "science fun" (Vesilind & Jones, 1996). Elementary teachers are generally responsible for staying current in a number of subjects, science being only one of them. Weiss (1994) concluded that it was not surprising that the typical elementary teacher spent less than 16 hours of inservice education in science in a three year period. Raizen & Britton (1993) reported that half of all elementary school teachers had taken their last course more than ten years ago; fewer than 30% had taken college-level science courses within the past five years. Raizen and Michelsohn's (1994) data showed the teachers least prepared in science are the ones least likely to participate in continuing education science courses. Roychoudhury (1994) found in her study of inservice teachers that they increased their science teaching time after attending workshops of three to four weeks in length where they were actively engaged in numerous hands on activities and had received recipe type instructions and lessons to use in their classrooms. Roychoudhury discovered that the inservice elementary teachers shaped new approaches to their pre-existing practice. Teachers added hands on approaches to their teaching while still retaining the transmission of the correct information to their students as the underlying goal in science teaching. They relied on the "recipe" approach, guiding their students through the steps of hands on activities with minimal attention to conceptual development. Many times the activities served to help students re-learn what they had previously studied. Roychoudhury found that teachers tended to explain or summarize what students were to learn rather than letting the students talk about what they had learned.

Crocker, Shaw, and Reed (1990) found that personal success with early experiences in using hands on science activities in the classroom impacted the continued use of this strategy by inservice teachers. Support by the school, especially the custodian, also influenced their decision to use hands on teaching methods in connection with the textbook in science. However, if the custodian complained about the messy room, teachers were more likely to discontinue science activities. Wallace and Louden (1992) found that elementary teachers often revert to their established way of teaching following a brief trial with interactive teaching unless they are given encouragement. This was further confirmed by Neale, Smith and Johnson (1990) in a study where teachers reported slippage into their old methods when they did not receive support from their peers and the instructors who had coached them through a light and shadow unit.

Preservice Elementary Teacher Science Background

Researchers believe that most preservice elementary teachers lack an adequate knowledge base in science when they leave their teacher education programs (Crawley & Arditzoglou, 1988; Doby & Schafer, 1984; Ginns & Watters, 1995; Lawrenz, 1986; Meching et al., 1982; Stephans & McCormack, 1985; Stevens & Wenner, 1996; Tilgner, 1990;Wiesman & Smith, 1997; Wenner, 1992; Zeitler,1984). Stephans and McCormack (1985) studied the levels of understanding of selected science concepts typical of freshman and senior elementary education majors. They used a 50-item multiple choice concept attainment assessment, a validated and reliable instrument developed by H.G. Christman. This instrument incorporated a cross-section of science concepts that are ordinarily included in elementary science programs. Both groups in the study had completed the required general science courses for an elementary major. Stephans and

McCormack found that senior elementary education majors achieved a mean score of 52.8 on the science knowledge test, only slightly higher than the mean of 49.1 achieved by the freshmen. They also reported that the students in the study demonstrated no particular strength in any of the sciences.

Wenner (1992) used the General Science Test: Level II (Australian Council for Education) with a reliability of 0.74 (Cronback Alpha) to determine preservice teachers' knowledge in earth science, biology, physics, and chemistry. The test was administered to 167 preservice teachers enrolled in a science methods course. He reported that the average preservice teacher responded correctly to slightly fewer than 50% of the questions. A replication of this study done by Stevens and Wenner (1996) found similar results. The same test was administered to 67 preservice elementary teachers, who responded correctly to approximately 50% of the questions. The actual range of scores was from 6 to 24 of 30 questions. Since this science test was not administered to other groups on the same college campuses, it is not known if preservice teachers scored lower or higher on the average than the general college population. These findings are consistent with several earlier studies of science knowledge among preservice teachers (Blosser & Howe, 1969; Leinhardt, Putman, Stein, & Baxter, 1990; Victor, 1962) leading Stevens and Wenner (1996) to conclude that if scores on the General Science Test that they collected were representative of contemporary elementary preservice teachers, there has been little improvement in the level of scientific knowledge of elementary preservice teachers during the past 30 years.

Tilgner (1990) surveyed 45 colleges and universities with a large number of teacher education graduates each year to find out their requirements for preservice elementary teachers. She discovered that not all colleges require elementary education majors to take science content courses. Only 18% of them required content courses in the three major areas of science: life, physical, and earth. While 74% of the institutions required a lab science, many of them allowed physical geography courses to be used to meet the requirements for a lab science even though "its content may have little relevance to science taught in the elementary school" (Zeitler, 1984, p. 514). Science methods courses, emphasizing process and methods of teaching rather than science content, were required at 93% of the institutions.

Tilgner (1990) also discovered variance in the state certification requirements in science for elementary teachers. Thirty-six states required that elementary teachers have science before being certified, but only seven states required elementary teachers to have taken science content courses for certification. Mechling, et.al (1982) reported that one-fourth of the states required completion of a science methods course for elementary certification.

Other researchers looked at the number and type of science courses taken by elementary education majors. Young and Kellogg (1993) and Duschl (1983) discovered that preservice elementary teachers usually take only the two or three science courses required for their major. They also tend to select lecture rather than laboratory classes. Zeilter (1984) found that preservice elementary teachers select introductory courses to fulfill their science requirements and seldom take second-level or advanced courses. Victor (1962) felt that this pattern of avoiding challenging or in-depth courses in science leads to the lack of development in the science area and perpetuates the inadequate science backgrounds of preservice teachers. Life sciences are the courses most commonly taken by elementary education majors. Biology is the most popular course, followed by nutrition (Stephans & McCormack, 1985; Young & Kellogg, 1993; Zeilter, 1984). Zeilter's (1984) study showed that 93% of elementary education majors had previously taken biology in high school. He hypothesized that preservice teachers take biology because they are able to build on their prior knowledge at the college level. Future elementary teachers usually take physical science courses at the high school level but infrequently at the college level. Lack of college study in physical science results in preservice teachers relying on information learned in secondary physical sciences and coincidental information they have acquired in various ways (Ginns & Watters, 1995; Lawrenz, 1986; Tilgner, 1990; Young & Kellogg, 1993; Zeitler, 1984). Ginns and Watters (1995) felt that this pattern diminishes the probability of the preservice teachers developing a background in physical science.

Many of the concepts covered in elementary science textbooks are related to physical science. Consequently, several studies have focused on the physical science knowledge of preservice elementary teachers (Gabel, Samuel, & Hunn, 1987; Ginns & Watters, 1995; Tilgner, 1990). Doby and Schafer (1984) found that 19 of 22 preservice teachers in their study did not understand the concept of pendulums. After receiving information through lectures and demonstrations, one-third of them still did not understand pendulums well enough to pass a simple test about them. Gabel, et al. (1987) designed a 14-item nature of matter inventory picturing atoms and molecules in circles of various sizes and shades. Preservice teachers were asked to draw pictures to show how atoms and molecules would look after a specified chemical or physical change occurred. A majority of preservice elementary teachers demonstrated a distorted view of matter and could not distinguish among solids, liquids, and gases. For example, they pictured gas molecules moving in an orderly rather than in a disorderly manner, and showed atoms becoming larger rather than moving farther apart when liquids changed to gases. Gabel et al., conceded that although their inventory showed preservice teachers held misconceptions about chemistry concepts found in most elementary textbooks, chemists might also make mistakes on the picture inventory depending on the attributes they chose to focus upon.

Crawley and Arditzoglou (1988) tried to identify preservice elementary teachers' understandings of eight concepts in physical science: motion, electricity, density, states of matter, heat, temperature, air pressure, and light. Their results showed that preservice elementary teachers had a number of misunderstandings in each concept area studied. They concluded that preservice teachers were familiar with the scientific terminology yet tended to have a superficial understanding of the underlying processes and concepts implied by the terms. The preservice teachers in Wieseman and Smith's (1997) study used the scientific terms of "pressure" and "density" to explain buoyancy in a sinking and floating problem but lacked understanding of these terms in their explanations of the concept, leading Crawley and Arditzoglou to conclude that preservice teachers use vocabulary without understanding it, "satisfying a concern to fit scientific terms into explanation" (p. 10).

Ginns and Watters (1995) probed the understandings of 321 elementary education students on floating and sinking, nature of matter, air pressure and its effects, and the balance beam. They found that 37% of the preservice teachers could demonstrate partial or complete understanding of density in relationship to sinking and floating or explain air pressure in relationship to liquids rising in a straw. Only a small percentage could explain their answers to the question on the nature of matter because it required them to understand the particle theory and to describe the properties and behavior of matter. However, 70% of the students who had taken chemistry and physics in high school were able to provide scientifically acceptable answers to most of the questions. Ginns and Watters concluded from their study that "many prospective elementary teachers demonstrate a range of inaccurate scientific concepts in the areas of science that form important components of the elementary science curriculum" (p. 219).

Preservice teachers also hold misconceptions in the area of life science. Crawley and Arditzoglou (1988) tested 49 preservice elementary teachers enrolled in a science methods course on life science concepts. These concepts were identified from elementary science textbooks and were ones that preservice teachers were expected to understand and teach them in the elementary grades. The greatest number of misconceptions (57%) were found in concepts relating to the human respiratory and circulatory systems, evolution, and prey-predator relationships. Other misconceptions were present in topics on living and nonliving things, human digestive system, and plants. Crawley and Arditzoglou concluded that preservice elementary teachers develop naïve theories regarding specific life science concepts needed for teaching them to elementary students.

> Teachers do not realize that some of the concepts--which they assume to be scientifically acceptable--are actually faulty or incomplete. Knowing "what" not "how" leads to rote learning in which students recite their knowledge but do not use it. (p. 18)

Conflicting conclusions exist regarding the relationship among background preparation, science knowledge, and proclivity toward teaching science of preservice elementary teachers. Positive relationships among these three have been shown in some studies (Crawley, 1991; Manning, Esler, & Baird, 1982), while others (Feistrizer & Boyer, 1983; Stephans & McCormack, 1985) have shown no relationship or even a negative relationship. Wenner (1992) undertook an investigation to update understanding of the relationship between the attitude held by prospective teachers regarding their ability to affect science learning among elementary students and their level of science knowledge: the attitude-knowledge relationship. Using descriptive statistics, a negative correlation of –0.27 was found between knowledge level and attitude toward teaching science. In other words, on the average, preservice teachers with stronger beliefs about making a difference in teaching science had lower knowledge scores. The Science Teaching Efficacy Belief Instrument (STEBI) (Enochs & Riggs, 1990) was used by Wenner (1992) to assess the beliefs about science held by preservice teachers. More than half of the respondents (56%) indicated that they could teach science effectively, and 46% of the 167 preservice teachers thought they had the ability to understand science concepts well enough to teach it in the elementary classroom. Yet only 15% thought they knew the steps necessary to teach science concepts effectively, while only 29% felt confident enough to monitor science experiments. Contradictory results were found in the level of confidence displayed by the respondents in their ability to answer student questions. Ninety-one percent indicated they welcomed questions on science topics, but only 2% felt they were able to answer the questions. Interestingly, 51% of the preservice teachers indicated a willingness to be observed teaching science. Wenner, whose study was described earlier, concluded "the students are confident in their general teaching competence and in their ability to impart facts but harbor doubts relating to their ability to teach science at a conceptual level or to conduct process oriented hands-on programs" (p. 466). In a later study, Stevens and Wenner (1996) found no significant correlation between the beliefs about teaching science of 67 preservice teachers and their science knowledge. While the average preservice teacher in this study scored 47% on a science knowledge test, 60% of the preservice teachers felt confident in their ability to teach science effectively, yet only 4% claimed to understand science concepts. Seventy-eight percent of these preservice teachers felt that good teaching could overcome inadequate science background of the teacher in children's learning of science. Their beliefs about teacher responsibility for learning were consistent with Wenner's 1992 study which found that 63% of the preservice teachers studied believed that student achievement was due to teacher effectiveness, and 65% believed that student improvement was due to extra teacher effort. Wieseman and Smith (1997) found that 15 of the 17 preservice elementary teachers completing a physical science course felt comfortable in their understanding of physical science and felt ready to teach physical science to students. When these students were asked to identify specific concepts they could easily teach, some listed only one while others identified as many as 9 out of 19. However, the students who scored the lowest on tests of knowledge of concepts in physical science felt they could teach more of the concepts than the majority of the class.

Preservice elementary teachers perceive imparting information to students as the main purpose for teaching science (Tilgner, 1990; Zeitler, 1984). Science is viewed as a collection of facts that students need to learn (Gee, 1996). Other purposes for teaching science perceived by preservice teachers and reported by Zeitler (1984) are developing an awareness of the world and teaching problem solving. Teaching science processes was considered the least important reason for teaching science. The perceived purposes for teaching science may be a reflection of preservice teachers' past experiences in school (Gee, 1996; Mulholland & Wallace, 1996; Stoddart, et al., 1993). Young and Kellogg (1993) reported from their study of 96 elementary preservice teachers enrolled in a science methods course that active involvement in science classes at any level was not a common background experience for most preservice teachers. The typical science class elementary preservice teachers remembered from grade school through high school and college consisted of presentation of scientific facts and principles through the use of textbooks, teacher lectures, and verification-type laboratories. Memorization was common to most science classes. Some of the preservice teachers in Mulholland and Wallace's (1996) study remembered science in high school as difficult and reserved for the "intelligent people" (p. 23).

Young and Kellogg (1993) alleged that many preservice teachers enter science methods courses with limited conceptual understanding of scientific ideas but expect that the course will prepare them with the content and the pedagogy to teach all areas of elementary science. Abell and Roth (1994), Appleton (1992), and Lawrenz and Cohen (1985) asserted that methods courses can produce more positive attitudes towards science and give the students more confidence about teaching science. However, Strawitz and Malone (1984) felt that a methods course did not guarantee that participants will develop the behaviors and attitudes required to implement activity-oriented science in their classrooms. Duschl (1983) contended that a science methods course can produce an "antagonistic dilemma" within preservice elementary teachers, as they are faced with focusing on the process of science over the content of science. They must learn how to work with both the process and content within the same context. Watson and James (1997) reported that as preservice teachers work on learning the process of teaching science using a hands on approach, their knowledge of and attitude towards science can improve. Huinker and Madison (1997) reported that although some students enter the science methods course confident in their knowledge and ability to teach science, they are likely to experience a change in their attitude about science as they realize science teaching may not be as easy as they thought. Stofflett and Stefanon (1995) found that methods courses that include a practicum help the preservice teacher understand the methodology of teaching science. The practicum gave them the_opportunity to explore science both as a learner and a teacher. The preservice teachers were excited to teach science in a classroom when they had experienced success in the field and felt their students had fun when they taught.

Research revealed that science is a subject that most elementary teachers do not feel comfortable teaching. Science instruction is usually textbook based in elementary schools. Researchers further showed that preservice teachers, upon leaving a teacher preparation program, have taken two to three introductory science courses and science methods. Preservice teachers hold misconceptions about science concepts in life and physical science but believe they will be able to teach science in the elementary school. A look at the research on beliefs and images of teaching provides an insight into this conception held by preservice teachers.

Beliefs and Images of Teaching

Preservice teachers begin their teacher training with various ideas about teaching and their professional development. Their beliefs about teaching originate in childhood when, as pupils, they experienced and acquired the norms and expectations of schooling (Hawkey, 1996). They have images of teaching that evolved from their past experiences and from the guiding actions of previous teachers (Johnson, 1992). Prospective elementary teachers are so familiar with the surface activities of elementary classrooms that they may enter the study of professional education believing they already know what teaching is all about (Weinstein, 1990). Britzman (1986) states:

> Prospective teachers bring to their teacher education more than their desire to teach. They bring their implicit institutional biographies--the cumulative experiences of school lives--which, in turn, inform their knowledge of the students' world, of school structure, and of curriculum. All this contributes to well-worn and commonsensical images of the teacher's work. (p. 443)

Preservice teachers believe they know the task of teaching from their observations of teachers. They think they understand teachers because they have learned to predict their behavior (Britzman, 1991).

These beliefs constitute what has been referred to as folk pedagogies (Bruner, 1996) or personal history-based lay theories (Holt-Reynolds, 1992; Wentworth & Pinnegar, 1996) because they have been constructed on the basis of personal experience and cultural beliefs, some of which may be of very long standing. These beliefs can affect the preservice teachers' attitudes toward professional preparation and their experiences in learning to teach (Weinstein, 1990).

Research suggests that preservice teachers enter preparation programs with confidence in their ability to teach and a lack of appreciation for the complexity and uncertainty of the teaching learning relationship (Weinstein, 1989, 1990). Anderson et al. (1995) point out that the views of learning and teaching held by prospective preservice teachers when they enter teacher education programs are potentially limiting. They believe that teaching is a process of transmitting intact bodies of knowledge to students and that students' ability to learn is dependent upon their home backgrounds. Feiman-Nemser, McDiarmid, Melnick, and Parker (1988) found that prospective elementary teachers begin their introductory education courses believing teaching is telling and that learning is reproducing what the teacher says. Futhermore, they tend to believe that teaching is easy and that teachers do not have to know very much.

> Students view teaching as a sum of a set of behaviors--talking to students, lining them up to go to the gym, comforting them, shushing them, and so on. To be a teacher one only need to act like a teacher. (p. 9)

Similarly, a study by Hollingsworth (1989) indicates that fully half of the 14 preservice teachers she studied initially believed that learning was primarily accomplished through teacher-directed information. Subject matter such as mathematics is perceived as a set of skills and procedures students must learn, and science is viewed as facts student need to learn (Calderhead, 1991).

Prospective teachers' implicit beliefs and images of teaching serve as a filter through which the teacher education program and others' teaching performances are viewed. Thus, information from university courses, and even from classroom observations, is translated and absorbed into the student's own pedagogy, making such material potentially miseducative (Kagan, 1992)

Initial preconceptions of teaching can remain intact at the end of teacher preparation (Anderson et al., 1995; Kagan, 1992; Stoddart, et al., 1995). Holt-Reynolds (1992) found that preservice teachers believed that students could be active participants in instruction while listening to a lecture; whereas the methods instructor believed that listening was an inherently passive event for the students. This unrecognized difference in the belief of the preservice teachers and the methods instructor prevented the possibility of any change in prior beliefs during the methods course or connected field experience. Hollingsworth (1989) examined cognitive changes in preservice teachers who were enrolled in a nine-month graduate teacher education program which focused on reading. She found that whereas some participants restructured their views of learning, others merely fine-tuned their preprogram beliefs. She concluded that differences in post program beliefs about learning corresponded to preservice teachers' notions of how students learn in school.

The affective, interpersonal aspects of teaching are heavily present in preservice teachers' preconceptions of teaching (Brousseau & Freeman, 1984; Calderhead, 1991). The affective dimensions of teaching emerged in Bullough's (1989) case study of a first-year teacher who seemed to envision teaching as "nurturing." In Hollingsworth's (1989) study, 13 of the 14 subjects believed that good classroom management was achieved by relating to pupils as equals; all of these teachers struggled with classroom control. A vision of teaching that emphasizes affective dimensions may give prospective teachers unrealistic optimism about future teaching performances (Weinstein, 1990).

Prospective teachers who are convinced that they have the qualities of caring, understanding, patience and the ability to relate to young people feel confident about their future success as teachers. This view is consonant with the myth that teachers are born or self-made (Britzman, 1991).

Teachers develop images of teaching based on their personal biographies, classroom situations, institutional organization, and university teacher education (Kettle & Sellars, 1996). The images are a means of representing how individual teachers view themselves in the teaching construct which influences, in turn, the way they teach. Images are not usually consciously articulated without some assistance, but they form the subconscious assumptions on which later practice will be based (Johnson, 1992). Connelly and Clandinin (1988) explain how images are related to experiences and become embodied in us as persons, and expressed through language and actions.

> An image reaches into the past, gathering up experiential threads meaningfully connected to the present. And it reaches intentionally into the future and creates new meaningfully connected threads as situations are experienced and new situations anticipated from the perspective of an image. (p. 60)

Images can be a useful tool for understanding a teacher's practical knowledge. They provide a language of practice for teachers. They are a basis for the decisions teachers choose about their teaching. They are a useful way of representing knowledge that can be translated into action in the classroom and can synthesize large amounts of knowledge about teachers, children, and teaching methods (Calderhead & Robson, 1991). Beliefs used to create these images hold several properties that distinguish them from knowledge: (1) they sometimes contain assumptions about the existence of entities beyond the teacher's control or influence, (2) they can include conceptualizations of ideal situations that differ from reality, (3) they rely heavily on affective and evaluative components, (4) they derive much of their power from memories of specific events, (5) they are not open to critical examination or outside evaluation, (6) the domains to which specific beliefs may apply are undefined (Nespor, 1987).

Calderhead and Robson's (1991) study of student teachers found that the images of teaching developed by preservice teachers were based on both the positive and negative images of past experiences. The negative aspects of past teachers, such as intolerance, impatience, and distance from children, stood out along with the positive influence and good teaching of one or two particular teachers viewed as role models. Preservice teachers linked the positive images of these role models to particular personality attributes of their own, reinforcing the appropriateness of the model to the kind of teacher they saw themselves becoming. They used their images of teaching as the ideal to achieve during student teaching. They based their interpretation of the practice of the supervising teacher and their first attempts at teaching on this framework. Preservice teachers entered the student teaching experience with their images of teaching at various stages of development. The images held by the student teachers in Calderhead and Robson's study ranged from dominant detailed images of teaching to waiting to be shown by the classroom teacher how to teach. These researchers concluded that student teachers' images tend to be inflexible. Their images are fairly restricted, rigid, and insensitive and usually focus on a few specific kinds of activity. Most of the student teachers were concerned with their own actions and not with student response.

> Student teachers seem to lack the knowledge about children, the curriculum and alternative strategies to manipulate the images they had in mind. The students tended to rely on models of good teaching as recipes that can be implemented in any situation and they lacked the knowledge or skills to adapt, question, and modify them either before or during their enactment. (p. 6)

Johnson (1992) studied two student teachers placed in the same classroom for their practice teaching. Although similar in background and context, they held different images of teaching. Laura felt that establishing a good relationship between her and the children was important. She envisioned that she would establish a channel of communication within the classroom that would enable students to plan their own learning and make suggestions of what they wanted to learn. She used this image when she made choices about strategies and discipline in the classroom. She found that parameters needed to be set in her relationships with the children. She wanted to be friendly but not too friendly. Marilyn, the other student teacher in the study, imaged teaching as giving control to the children. She wanted to organize time so that children were able to pursue their own agendas. She realized that her image was too ideal as she struggled with putting her ideas into practice. She found it necessary to place parameters on her thinking and incorporate cooperation and teamwork in her image to make it work. Although student teaching takes place in an environment that has already been set and built and contains constraints that may hinder putting personal images of teaching into practice, the author concluded that student teaching does give teachers a setting in which to modify, clarify, and refine images and find parameters that can guide practice in different settings.

In a later study, Johnson (1994) observed and interviewed two student teachers as they grappled with the dilemmas they encountered in their first experiences with teaching. She used their images of teaching to explore their perspectives on the experience. One of the subjects in her study, Roger, an African-American in his mid-twenties, believed that each child in the classroom was important and he felt the need to ensure that each of them learned. During the early stages of practice teaching, he was concerned that his image was not being realized to the extent that he wanted. His limited repertoire of teaching strategies and his reliance on intuitive ideas of teaching aimed at doing things differently from his own school experience hindered his progress in making his image a reality. He was seeing teaching from the somewhat simplistic point of view of how it is perceived by students (Lortie, 1975). Roger's image of teaching changed completely by the end of the semester. He now believed that structure and regimented control mechanisms were needed to get children involved in learning, and continuous repetition would help children achieve learning. He had distanced himself from the children and had put aside the flexible, individualized approach he had once envisioned. In contrast, Diane, the other subject in the study, entered her student teaching with a clear image of teaching. She felt it was important to respond to the individual needs of children, an image she developed during her experience as an early childhood teacher. She used her student teaching to clarify this image as she developed a repertoire of strategies which achieved and affirmed her image during her experience.

Kettle and Sellars (1996) attempted to chronicle the change in the practical theories of two student teachers over the time span of a year, beginning at the end of their second year of teacher training. The participants in the study differed in age and background, but both began with a simplified idea of what teaching involved. Ann, a 20 year old student, thought a good teacher was one students would like, and a good relationship with students was important. Janice, a 30 year old mother of school-age children, thought teaching was like parenting. These practical theories changed from broad concepts to specific aspects of key teaching principles over their year of experience. Ann dropped the idea that she needed to be liked after her first practicum and was able to focus more on the students. She felt that teaching should be a two-way street between teacher and students and wanted a comfortable environment in her classroom where respect between everyone was present. She found it difficult to implement her recripocal image of teaching because she shouldered too much of the responsibility for learning herself. Ann adopted many aspects of her supervising teacher's image of teaching during the last practicum, learning some strategies that enabled her to implement her image. Janice knew from the onset that her image of teaching was an ideal. She wanted the teacher to be a provider of experiences and students to be active communicators and learners, working in groups with hands on activities. Her image conflicted with her first practicum classroom experience causing her to question her decision to become a teacher. Despite this, she held onto her image and tried different strategies that might make it work for her during her second practicum. She eventually developed a more realistic outlook and became more flexible in her approach, which helped her implement a modified image. The researchers concluded that the evolution of the student teachers' practical theories of teaching in their study supported the literature which reports that student teachers enter teacher education with only partially developed theories. These theories are elaborated and refined throughout the course of training (Bullough & Knowles, 1991; Goodman, 1988) and are integral to their professional development.

Hawkey (1996) studied the incoming images of two preservice teachers and examined them for stability over the duration of a one-year graduate initial teacher education program. Both participants were history graduates, of similar age and background, and were placed in the same secondary school. Ella had already developed a clear image of herself as a teacher upon entering this program. She wanted to promote a positive relationship with her students. Even though Ella ended up modifying her image as she moved through the process of becoming a teacher, her image remained stable and constant through her first teaching experience. John, like many other beginner teachers, conformed to the norms of the school and used this as a model for his own development. He was uncertain about his image and he preferred to model his teaching according to the expectations of the school. He could not conceptualize a starting point for his own individual outlook of teaching and did not think about his development as a teacher or learner.

Sometimes teachers enter their first year of teaching with a definite image of themselves as a teacher and find that their images conflict with what is expected in the school environment. Kara, in Kuzmic's (1993) study, felt strongly about creating an environment in her classroom in which she could individualize instruction to fit the needs and abilities of her students and through which students could begin to develop a sense of responsibility for their own education. She also wanted them to begin to make some of their own choices about learning. Her image of teaching was formulated prior to being contextualized in a school setting. Her image proved to be particularly resistant to change and impacted her ability to examine critically her teaching and her situation. Kara did not want to discard her image but the difficulties she was encountering threatened that image and her confidence. She did not see many of the problems and difficulties she experienced as external and dependent upon the context in which she was teaching; rather she internalized them, seeing them as limitations or faults in the way she was teaching. This produced a conflict between the image she had of herself and her teaching and the realities of the classroom and school life. She tried to ignore her difficulties and continued to teach to her image. Gradually, she began to distance herself from the image she had of herself as a teacher and began to see herself in the context of the situation. She was then able to modify her image in subtle ways to correspond to the exigencies of her situation.

Literature on images of teaching science is scant. Brickhouse and Bodner (1992) describe the conflict between the beliefs and practice of a second-year middle school teacher. McGee, the subject in the study, believed that science should be an informal experience where kids are "messing around" and "going off on tangents." In practice, his classroom was a formal structured environment. He imparted knowledge to his students in a structured way before any "discovering" was allowed. His discovering consisted of labs that were highly structured, and students were not allowed to deviate from the set instructions and questions. The authors concluded that McGee had not developed an image of teaching that fit his belief that science was an informal activity.

Marie, the subject in Abell and Roth's (1992, 1994) studies, held a strong image of science teaching using a hands on approach full of relevant experiences to motivate and actively involve students in learning science. She also believed that science was for all students. She was called a "science enthusiast" by the authors. Because of her strong desire to make science an integral part of the curriculum during her student teaching, she found ways to overcome the constraints she encountered as she worked to achieve her image. The authors concluded that Marie's extensive classroom experiences in science prior to her student teaching had provided her with strategies to help make her image of science teaching a reality during this experience.

Tobin et al. (1990) studied a teacher who knew her first vision of mathematics and science teaching was inappropriate. She tried to be an actor, to compete with television, and control every bit of knowledge that was given the students. She left teaching after five years because of her dissatisfaction. When she came back to teaching seven years later, she searched for a vision of what she wanted her science teaching to look like. She decided that she wanted her students to be actively involved in constructing knowledge that would be useful to them in everyday life. She also wanted them to be engaged in experimentation and cooperative learning. Her new image was realized because she sought out training and developed strategies that helped her to implement it.

The Process of Becoming a Teacher During Student Teaching

Stages

Learning to teach is a complex, challenging, and often a painful experience. Over 20 years ago, Fuller and Brown (1975) stated that when students are learning to teach, they feel stimulated, apprehensive, exposed, endangered, confused, discouraged, touched, proud, and lost. It appears that nothing much has changed over the years (Furlong & Maynard, 1995).

Student teachers go through a development process as they learn to teach. Fuller and Brown (1975) did one of the most influential studies in this area. They identified and labeled three discrete stages of student teachers' development: survival, mastery, teaching performance and concerns about the learning, social, and emotional needs of the students and their ability to relate to them. Calderhead (1989) also recognized three phases in learning to teach: fitting in, passing the test, and exploring. He suggests that student teachers view their first task as fitting into the cooperating teacher's routines. By the middle of their assignment, they feel they have to adopt particular types of behavior that signal competence and later they experiment with classroom organization, subject matter and different types of lessons, staying at a surface level.

Concerns about self, survival, teaching tasks, pupil learning, materials, and curriculum development can occur simultaneously and are dealt with concurrently by the student teacher (Burden, 1990). Guillaume and Rudney (1993) found that student teacher concerns about lesson planning and evaluation, discipline, working with students, adjusting to their classrooms, and transition from student to professional teacher were held simultaneously by student teachers throughout their school experiences, but the nature of their concerns shifted as students began to take on more responsibility as teachers. These researchers maintained that development is a general process: student teachers move toward more complex thought patterns as their learning, experience, and responsibility as teachers increase. Their development from a novice to professional educator is complex, erratic, and "unique to them as an individual" (Furlong & Maynard, 1995, p. 70).

Furlong and Maynard (1995) discerned five broad, interrelated stages in student teachers' development during their student teaching experience. They characterized their stages as early idealism, personal survival, dealing with difficulties, hitting a plateau, and moving on. These stages provide the means for student teachers' to gain control over their own teaching as they form more sophisticated concepts or "ways of seeing."

Furlong and Maynard (1995) identified the first stage of student teaching as the early idealism stage. During this stage, student teachers tend to identify with the pupils rather than the teacher. They are often unsympathetic or even hostile to the classroom teacher. They carry with them snapshots of teacher behavior, what teachers should and should not do in the classroom. Teaching and learning are commonly seen in a simplistic way. Student teachers are idealistic about the kind of relationships they will develop with their pupils, the physical appearance of the classroom, and the classroom atmosphere they will create. They want to be seen by the pupils as warm, caring, friendly, enthusiastic, and popular. They want to develop a balance of friendship and respect in their relationship with the students, believing their effectiveness as a teacher will be determined by this relationship.

The personal survival stage is the next stage in student teacher development. This stage usually lasts only one or two weeks and can be a period of great stress for student teachers, who feel a mixture of fear, anger, frustration, and exhaustion. Student teachers go through the process of detecting and fitting in with the teachers' routines and expectations, being seen as a teacher, and achieving some form of classroom control. They are hesitant to assert their authority as a teacher because they fear the pupils will not respond to them. They perceive that both the teacher and the pupils hold power in the classroom. Student teachers often respond to their need for survival by trying to copy the teacher's style, particularly in relationship to the children. They conform their ways to the teacher (Schoonmaker, 1998) to help them be seen as a teacher. The ideal teacher they initially wanted to be is put on hold and temporarily replaced by the teacher they have to be in order to survive. Their teaching and the content of student activities are influenced by the amount of control they feel they have over the students at this stage. They rush through lessons, tend to give one on one interaction with pupils, or let the students control the class. They are afraid to deviate from their lesson plans even when headed for disaster.

Once student teachers have experienced some teaching, their concern shifts from personal survival to survival as a teacher. Furlong and Maynard (1995) refer to this stage as dealing with difficulties. Student teachers adopt the outward appearance of being a teacher as they try to gain a procedural understanding of what it means to be a teacher by mimicing what they believe to be teacher behavior. They worry about failure, wonder what other people think of them as a teacher, and feel inadequate when criticized by the teacher or when poor feedback is received from the pupils. Student teachers begin to focus on their performance and to impress the students with their teaching strategies and classroom organization. They think if they make their lessons interesting enough, the students will sit and listen. They like to work with the whole group, where the attention is focused on them, and are reluctant to try small group tasks. They compensate for their lack of knowledge and control by elaborate preparation, usually without consideration for the children's learning. They tend to adopt and adapt their teaching as they discover that pupils respond better to known ways of working.

The fourth stage, the plateau, comes once student teachers have gained basic competence and confidence in management and organization. There is a tendency to relax as they hit the plateau. At this point their teaching is still shallow. They have not developed an understanding of the relationship between teaching and how children learn. They tend to stick to the strategies they have found to work for them, their enthusiasm to try new strategies wanes, planning becomes sketchier, and inappropriate shortcuts are used. The content of the lessons and activities is still simplistic: the student teacher thinks a lesson was successful if the pupils enjoyed it or seemed interested.

Furlong and Maynard (1995) refer to the last stage in student teaching as moving on. Student teachers can rarely see beyond what they want or need to do, or what the classroom setting requires (Feiman-Nemser & Buchmann, 1987, p. 272). During this stage, student teachers need to be challenged to re-evaluate and look at the broader implications of their activities in terms of student learning. Some student teachers resist looking at their teaching in terms of student learning.

Furlong and Maynard (1995) describe the stages as broad patterns of development, whose progress is likely to be fragmentary and erratic. Student teachers may be able to develop and use more advanced understandings in one context but not be able to generalize them to the whole of their practice. Stages may be revisited during the experience. Student teachers may be plunged back into focusing on their personal survival when they try new approaches and the pupils become disruptive. Personal factors may influence the manner in which student teachers progress through various stages. Contextual factors also come into play. Student teachers' progress can be affected by lack of communication between the cooperating teacher and the student teacher, two strong personalities in the same classroom, and most importantly the cooperating teacher's willingness to relinquish power to the student teacher. Spector (1989), in her seven-year study of 309 science teachers, found that science teachers typically progress through five stages of professional development: induction, adjustment, maturation, mid-career crisis, and leadership. Elementary student teachers, when learning to teach science in the classroom, appear to fall into the induction stage. Science teachers at this stage are usually textbook bound, avoid laboratory activities because they fear they will lose control of their students, prefer to be told the best way to teach, use convenient activities that students can do with the "recipe" method, rely on the lecture/demonstration approach, and ignore the individual student's learning needs. They feel there is a large gap between what is feasible in the school and what was learned in their teacher preparation courses. They concentrate on the "how to" rather than the "why." Some student teachers may even begin to move into the second stage identified by Spector, the adjustment stage. During this stage, they focus on presenting subject matter. They will give students generalizations and conclusions rather than letting them generate ideas or learn from activities. They still rely on convenient instructions that focus on confirming information when doing infrequent laboratory activities.

Student teachers move through stages during their student teaching experience as they develop into teachers. Furlong and Maynard (1995) identified five stages, early idealism, personal survival, dealing with difficulties, hitting a plateau, and moving on, which they believe student teachers move in and out of as they encounter new experiences in student teaching.

Mentoring and instruction also play a role in the developmental process of being a teacher during student teaching. Research on these areas is presented.

Mentoring

Mentoring has been advocated in the education field as a means for promoting excellence in education (Healy & Welchert, 1990), bring change in practice (Abell, Dillon, Hopkins, McInterney, & O'Brien, 1995) and to support beginning teachers as they learn to teach (Heller & Sindelar, 1991; Odell & Farraro, 1992). The potential value of mentoring during the beginning stages of teaching can effect the quality and professional growth of novice teachers. Preservice teachers require support and assistance from others to help them grow and develop as teachers (Huling-Austin, 1986).

Mentoring is defined in different ways. Levinson (1978) describes a mentor as "a teacher, a sponsor, host or guide, an exemplar that the novice teacher can admire and seek to emulate, may provide counsel and moral support in times of stress and most crucial, support and facilitate the realization of the dream" (p. 98). Anderson and Shannon (1988) define mentoring as follows:

> A nurturing process in which a more skilled or more experienced person, serving as a role model, teaches, sponsors, encourages, counsels, and befriends a less skilled or less experienced person for the purpose of promoting the latter's professional and/or personal development. Mentoring functions are carried out within the context of an on-going, caring relationship between the mentor and protégé. (p. 40)

Mentoring is different from the superior/subordinate helping relationships that might be found between teacher and teacher or supervisor and student teacher. A mentoring relationship must have reciprocity between mentor and protégé and accomplish an identity transformation by each party. In a supervisor/ teacher relationship, the supervisor shares materials and methods and helps to improve immediate problems or situations. A mentor, by contrast, will engage in interactions aimed at passing along his/her professional legacy, attempting to cultivate changes in the protégé's approach to tasks. The supervisor/subordinate relationship begins and remains an unequal relationship, whereas the mentor/mentee relationship becomes reciprocal over time. Mentoring relationships can be influenced by many interacting variables, including mentor/mentee personalities, shared history, and contexts which can inhibit or enhance the growth of the relationship (Healy & Welchert, 1990). Sometimes the initial mentor/mentee relationship never moves beyond the initial stage of supervisor/teacher. This is likely to occur if the mentor is also assigned as the evaluator of the intern. Crucial to development of the mentor role in the educational setting is a shared appreciation for the complexity of teaching (Abell, et al., 1995).

Anderson and Shannon (1988) feel there are five functions of mentoring: teaching, sponsoring, encouraging, counseling, and befriending. Within the teaching context, these mentoring activities would include demonstrating teaching techniques to a protégé, observing the protégé's classroom teaching and providing feedback, and holding support meetings with the protégé. Mentors must have dispositions that allow them to open themselves to their protégés, lead protégés over time, and express care and concern for both the personal and professional welfare of their protégés.

Furlong and Maynard (1995) suggest that mentoring during student teaching needs to be a developmental process as student teachers move through the stages of learning to teach. The mentor needs to model in the beginning stage, become a coach as the mentee begins to teach, develop into a critical friend to help the student teacher focus on student learning, and then become a co-inquirer as they work towards becoming more professional.

Student teachers felt the need for personal support as a priority during their student teaching, according to a study by Karmos and Jacko (1977). They found that student teachers sought both professional and nonprofessional mentors during their student teaching. They looked both for personal support and for support in their growth as teachers. The cooperating teacher was significant in their lives for their teaching role development and personal support. Friends, other student teachers, spouses, and other relatives also gave both personal support and help in developing professional skills. The authors felt that student teachers are concerned more with their feeling of personal worth and confidence than with the acquisition of competencies and skills of teaching, and that cooperating teachers, as mentors, need to address both areas.

Mentoring comes from various sources and serves different purposes in the developmental process of student teaching. Personal and professional support is needed by student teachers as they move into a teacher role.

<u>Instruction</u>

Student teachers hold multidimensional conceptions of instruction. A study by Ellwein, Graue, and Comfort (1990) examined 47 student teachers' conceptions of instruction during their student teaching experience. "Student reactions," "lesson implementation," and "uniqueness" dominated the informants' descriptions. Methods, materials, and activities that were creative or fun contributed to a lesson's success in their eyes. Student interest and participation characterized successful lessons. Well-implemented lessons were identified as those in which the student teacher would maintain the momentum, challenge students to think, and explain the material by creating links to previous experience or to real-life issues. Unsuccessful lessons were characterized by poor explanations, inefficient use of time, or attempts to cover too much material by the student teacher. Poor behavior management, preparation, or implementation were given as reasons for lesson failures. Misbehavior of individual students or groups was commonly cited as a reason for a lesson's demise. This is consistent with the findings of Borko, Lalik, and Tomchin (1987) who concluded that classroom management was "necessary but not sufficient to successful teaching." Nearly two-thirds of the student teachers in their study emphasized their role if a lesson was successful, but when a lesson was unsuccessful, the student role was more likely to be highlighted. Only a few student teachers took responsibility for unsuccessful lessons and saw the student role as important to successful lessons. The elementary student teachers in the study were more inclined to attribute lesson outcomes to their own dispositions. Nearly half mentioned nervousness, lack of self-confidence, or bad moods as factors in unsuccessful lessons. The authors concluded that student teachers are reluctant to engage in self-criticism because they have yet to develop this skill at a sophisticated level and are put in situations that normally do not encourage it.

The elementary school curriculum requires teachers to be knowledgeable in many areas. The typical elementary teacher cannot be expected to become an expert in all fields. Leinhardt et al. (1991) found that student teachers enter into their experience with more confidence about teaching some subjects than others. Even in the subjects with which they are comfortable, they display little knowledge of the central topics and concepts to be taught. They impart the content at a surface level because of an inadequate command of the content knowledge. They tend to structure their lessons around the affective elements of the topic to be taught rather than the cognitive. They focus on form rather than substance and find it difficult to adapt and use lesson plans in the classroom (Hill, Lee, & Lofton, 1991).

Dobey and Schafer (1984) studied student teachers and their methods of instruction. The student teachers were categorized in three stages: o.k., knowledge about pendulums, and little knowledge of pendulums. The researchers found that student teachers with little background knowledge of pendulums structured their lessons to be very teacher directed. They did not want to appear "unknowing to their students." They allowed for little student input of ideas and controlled the lesson activities in order to keep the student activity within their scope of knowledge. Their lack of knowledge limited student inquiry and activities. Student teachers with knowledge of pendulums wanted to share their knowledge with the students by explaining to them about each variable they were trying. They would interrupt the students while they were testing a variable to make sure they understood what they were doing or tell them more information and would move from variable to variable only after they thought the students understood what they were doing. The student teachers with intermediate knowledge of pendulums felt confident teaching about pendulums and let the students do more inquiry and discovery about the variables. They asked questions leading to more inquiry. The authors concluded that if teachers possess adequate knowledge on a science subject, they may be willing to engage students in inquiry learning. Abell and Roth's

(1992) study reinforced this finding. Marie, the student teacher in the study, taught most of her lessons on rocks with hands on activities, a topic she felt comfortable teaching. When she taught about oceans, a topic of limited content knowledge to her, she only included brief hands on activities in three of the lessons. She relied on text-based teacher directed lessons.

Student teachers may have personal goals that influence how they approach their teaching. Mellano (1997) found that the four preservice teachers in her study were more focused on achieving certain attitudes in students than learning the content even when knowledgeable about a subject. With the exception of one student teacher, the other three relied on intuitive strategies to teach the lessons on energy and the environment. This resulted in teacher explanations over active involvement. It confirmed what Tobin (1993) had earlier noted about preservice science teachers: they lack practical plans of action in specific classroom contexts, leading them to improvise a great deal in their manner of teaching.

Research revealed that student teachers usually use a teacher directed approach for instruction, are reluctant to engage in self-criticism of their teaching, teach at the surface level, and structure lessons around affective rather than cognitive learning.

The process of becoming a teacher is not static during student teaching but moves in and out of various stages of development. Professional and personal mentoring are needed by student teachers during their development into teachers. Instruction strategies are a reflection of the developmental process.

The next section provides a look at science teaching during student teaching.

Elementary Student Teacher Science Teaching

The research base concerning student teachers is broad and varied. Studies of elementary school student teachers and their experiences with science teaching are scant. An exhaustive search of the literature was conducted to find studies relating to science teaching by elementary student teachers. Five studies were found.

A study by West, Watson, Thomson, and Parke (1993) focused on the attitude and anxiety toward science and science teaching among 71 preservice elementary student teachers. They found a significant improvement in attitude towards science and science teaching and a decrease in anxiety about science and science teaching during the student teaching experience. In addition, their study revealed some information on time spent teaching science, how the student teachers perceived the importance of science in the curriculum, and the areas of science they liked to teach. All of the student teachers did experience science teaching during their student teaching. However, all of them ranked science in the lower half of importance of the subjects they were required to teach. Fifty-six of the 71 participants ranked it either fifth or last. None of them ranked it in the top three of the importance scale. Most of the student teachers reported spending 30 to 45 minutes planning their science lessons. The majority (42) of the student teachers reported teaching science five days per week. Yet, when asked how much time was spent instructing in science each week, the majority reported spending an average of 30-45 minutes a week actually teaching science. Fifteen of the students reported spending four hours per week instructing science and seven reported instructing two to four hours per week. Biology was the most popular science area the student teachers felt comfortable teaching (74%), geology was next at 50%, followed by chemistry at 25% and physics at 11%.

MacDonald (1994) described an observation of a student teacher teaching science and a follow-up interview. This was the only science lesson the student teacher taught during her student teaching experience because science was taught once every four weeks. Two factors influenced the student teacher's choice of materials and her teaching approach: management of the students and the cooperating teacher. Marcy, the student teacher, opted to teach the lesson along the same lines as her cooperating teacher rather than apply the principles she had learned in her science methods class because the teacher "knew what she was doing" and would be the ultimate evaluator of her teaching. Marcy spent most of her lesson "telling" instead of letting the students discover how ice wedging affects rocks. Yet, during the subsequent interview, she could articulate the principles learned in the methods course that she failed to apply in her teaching. MacDonald concluded that within the context of student teaching, student teachers would conceive what is reasonable to do under the circumstances and then act accordingly.

Abell and Roth (1994) conducted a case study of a student teacher teaching science. Marie, the student teacher, held strong beliefs and desires about science teaching as she entered into student teaching. She was enthusiastic about science teaching and was committed to trying new ideas. She had a drive to make science meaningful for her students. She was confident about teaching in general because of her prior teaching experiences and she felt comfortable managing groups of children. Marie's cooperating teacher was willing to let her try new ideas in her class, turning over the science class completely to Marie because she did not like to teach it. Marie modified the curriculum as she constructed her own style of teaching. She saturated the curriculum with science, doing hands on science activities outside of regular science periods. She used the textbook as a resource, and blended ideas from her college courses and prior teaching into the curriculum. She was able to do things in science that did not seem possible in the other subjects although she still felt pressured to satisfy curriculum coverage within the textbook-based science program. She became a catalyst within the system and engergized others to think about science in new ways.

A study by Gee (1996) focused on the science teaching of nine elementary student teachers. Six of the student teachers had a concentration in science and three had concentrations in other areas. The study sought to examine the level of elementary student teachers' science content knowledge, pedagogical knowledge, and pedogogical content knowledge. The attitude survey revealed that all of the student teachers held a positive attitude toward science teaching both before and after student teaching. Data also revealed that the student teachers espoused inquiry without always practicing it, admitted they did not know or understand all of the content they were expected to teach at the elementary level, and did not regularly incorporate teaching strategies into their lessons that had been emphasized in their science methods courses. It also revealed that the individual student teachers' ability to cope with classroom management concerns was directly related to their pedagogical content knowledge. In the classroom, prior to student teaching, students supported cooperative learning, the learning cycle, eliciting children's prior knowledge and problem solving as important to science teaching but ignored these aspects of pegagogy in real-life teaching situations. The student teachers were able to appropriately apply and adapt pedagogy for science concepts they felt comfortable teaching. While none of them demonstrated an adequate pedogogical content knowledge, the six student teachers with the science concentration displayed more confidence in their abilities to teach science to children. At the end of their student teaching, eight of the student teachers were enthusiastic and positive about teaching science in their own classrooms. They felt their pedagogical skills in science would develop in time, enabling them to teach science more effectively.

Whitworth (1996) studied two female student teachers during their science teaching in sixth-grade classrooms at a middle school. Both of the student teachers had taken five science content courses in their teacher preparation program and had been trained with the hands on science strategies advocated by the state reform. Marilyn, one of the student teachers, based her teaching of a unit on weather more on her own personal knowledge than the textbook although she had never taken a course in meteorology. She was frequently observed giving misinformation to her students. Yet, she felt she had sufficient knowledge to teach it. She used a lecture format to teach using notes based on her prior knowledge and the textbook. Laura, the other student teacher, often presented incomplete information when teaching about rocks and minerals. She taught from notes taken from the textbook, presenting them on the overhead and having her students copy them. Whitworth concluded that the student teachers used a teacher centered model of instruction because they did not feel comfortable with the topics they were teaching, and classroom management dissipated their early beliefs about student involvement in science.

Constraints

Teachers and student teachers construct knowledge about science teaching that fits the context of the classroom environment. This comes through interactions with students and the cooperating teacher (or student teachers), observing how students learn, and deciding what strategies may best be applied in a given teaching learning situation. They begin to perceive events and phenomena which could constrain their science teaching from a personal point of view (Tobin et al., 1990). Teacher constraints usually differ from the constraints perceived by student teachers during their short time in the classroom. Teachers view time for teaching science as an overwhelming constraint, especially in grades one through three if reading is heavily emphasized. Lack of supplies or inadequate facilities may become a constraint to some teachers, while the curriculum or textbook may be considered a constraint to other teachers (Johns, 1984).

The textbook or curriculum of a school is often felt to be a constraint to science teaching by teachers (Cronin-Jones, 1991) and student teachers (Abell & Roth,1992; Brickhouse & Bodner, 1992). The science textbook is the most important instructional medium in the elementary school and used as a tool for the majority of the science instruction in the classrooms (Weiss, 1994). Teacher input on textbook selection is minimal in most situations, as the science textbook is chosen as a series by a district selection committee. The science textbook often becomes an object of criticism by teachers, who feel constrained by the format of the book, its readability, its relevance to the everyday lives of the children, its breadth of topics, and the lack of materials to support the textbook activities. They also feel pressured to cover all the material in the textbook (Shymansky, Yore, & Good, 1991). Teachers respond to constraints perceived in science textbooks by implementing them in ways that fit their knowledge or priorities and by deciding which topics and activities are appropriate for their students (Smith & Anderson, 1984).

Cronin-Jones (1991) did a case study of two upper elementary teachers as they implemented a science curriculum on wildlife species. She found that their beliefs about how students learn, their beliefs about the teacher's role in the classroom, their beliefs about the relative importance of the content, and the perceived ability levels of the students all influenced the implementation process. For example, the curriculum had many activities that were intended to be done in small groups. However, neither teacher felt comfortable using this method, so they skipped those lessons or taught them in a whole group setting emphasizing factual knowledge. One of the teachers implemented most of the lessons because she had a positive attitude toward the curriculum, while the other one did not believe that all of the topics were important and eliminated many of the lessons. Marie, the science enthusiast, in Abell and Roth's (1992, 1994) study of student teaching, felt required to use the textbook even though it was inadequate. She used the book as a guide when teaching about rocks but seldom had the students read out of the book. She felt the book was "horrible, boring and told her nothing" (p. 590). When she taught about oceans, she began to use the textbook more because she did not have other resources available to her.

Assessment of student learning of curriculum is often viewed as a constraint by student teachers. They feel threatened about being held accountable for student learning when having to give tests of knowledge contained in the book (Abell & Roth, 1992). Student teachers and beginning teachers often adapt their teaching and move towards emphasizing the terms in the textbook so students will do better on the tests (Brickhouse & Bodner, 1992) or modify the test to match their teaching (Abell & Roth, 1992).

Time is another constraint mentioned by teachers as inhibiting their science instruction. They feel there is never enough time, especially when trying to do hands on activities (Neale et al., 1990), or that it takes too much time to prepare for hands on activities (Wallace & Louden, 1992). Group work and management of groups are perceived as constraints to adding hands on activities to science teaching. The concerns in this area are varied: how to involve all the children in the activity, how to cope with individual children who disrupt groups, how to keep groups on task, how to manage the higher noise level in classrooms, and how not to lose control of the classroom (Cronin-Jones, 1991; Neale et al., 1990; Schoonmaker, 1998; Wallace & Louden, 1992). Student teachers may also feel constraints from their cooperating teacher about trying or using groups in the classroom (Aafedt, 1992).

Summary

The literature review addressed the current state of science teaching in elementary schools and the background of preservice teachers in science. It was found that many elementary teachers feel uncomfortable teaching science because of inadequate background in science. Science is currently taught about 30 minutes a day in elementary schools and instruction centers around the textbook. Use of group work and other instruction tools is increasing. Preservice elementary teachers take two to three introductory science courses during their teacher training programs in addition to a science methods course. They typically take courses in biology. Physical science courses are not usually taken. Preservice teachers hold many misconceptions about concepts in all science disciplines. Preservice teachers enter their teacher training holding many beliefs about teaching based upon their prior experiences as students. They view teaching from the perspective of a student, usually focusing on the affective components of teaching. Literature on the images and beliefs held by elementary preservice teachers towards teaching in general and science teaching in particular was reviewed. Preservice teachers' beliefs are used to filter the ideas they learn in teacher training programs. Preservice teachers who form defined images of how they would like to teach find it difficult to implement them in the field until they acquire the needed teaching strategies.

Research on the stages of student teaching, mentoring, and instruction during student teaching was explored. Student teachers progress through stages of development leading them to develop more complex thought patterns as they gain expertise in teaching. Personal and professional mentors are important to student teachers. Instruction during student teaching is usually teacher directed and structured around affective learning during student teaching. Research showed that student teachers struggle with science content knowledge, have difficulty implementing hands on activities in their classrooms, and rank science as a low priority subject. Student teachers feel constraints on their science teaching because of time, curriculum, management, and assessment.

CHAPTER III

BACKGROUND AND METHODOLOGY OF THE STUDY

This study grew out of my personal curiosity concerning science teaching in elementary schools. Why is science such a neglected subject in the elementary school curriculum? Why do elementary teachers decide either to teach or to avoid teaching science in their classrooms? When does this decision occur? I sought to address these dilemmas through informal inquiry. I talked to other educators and teachers, gathered information from books and articles on science teaching, and attended conferences on science and science education, yet did not find a satisfactory answer. A more systematic approach was needed.

Interested in this educational issue for several years, I knew its study would sustain my interest over a prolonged period of time. This factor alone is critical when choosing a dissertation topic. According to Rudestam and Newton (1992), "There is nothing worse than slaving hour after hour on a project you abhor" (p. 10). Concern arose about becoming too ambitious in trying to tackle too amorphous a topic. I knew that most of the preservice teachers enrolled in the science methods courses I taught seemed interested in teaching science by the end of the semester. They thought it would be fun to teach children science and were anxious to try it. Given the level of enthusiasm observed in preservice teachers at the end of the science methods course, why was science instruction in the elementary school not increasing? What happened to their interest and enthusiasm when preservice teachers taught science during student teaching? Having narrowed the topic to looking at science teaching during the student teaching experience, I searched the literature to determine whether a study of this topic would fill a void or replicate, extend, or develop new ideas in the scholarly literature, another criterion for consideration when planning a research (Cresswell, 1994). Studies were found that measured student self-efficacy during science methods courses (Cannon & Scharmann, 1996; Enochs & Riggs, 1990) but not during student teaching. Scant literature was found on the experiences of elementary student teachers with teaching science (Abell & Roth, 1994; MacDonald, 1994). I became convinced that a study on elementary preservice teachers and their experiences and reactions to teaching science in the public school classroom would both fill a void and extend knowledge in the literature. This led to the formulation of my research question: How do elementary preservice teachers make meaning of teaching science during their student teaching experience?

Chapter III contains three sections. The first part discusses the selection of the method for the study. The second part describes the entry to the site, the selection of the participants, and the data gathering procedure. The last section reports on understanding the data.

Selection of a Method

The next step was deciding on a paradigm for use in the study. I did not feel that the positivist view of education as an object to be studied or the critical research view that education is an institution designed for social and cultural reproduction and transformation fit either my topic or my preferred role as a researcher. The interpretative or qualitative paradigm, that views education as a process and school as a lived experience, appeared to be the best choice for answering this question (Merriam, 1998). Firestone (1987) posits that assumptions about the nature of the work, the purpose of the research, and the role desired as a researcher all enter into the choice of the paradigm. Looking at the three attributes identified by Jacobs (1987) in qualitative research--it is conducted in a natural setting, stress is placed on the importance of understanding participants' perspectives, and questions and methods emerge in the process of fieldwork--confirmed my choice of paradigm.

My research question attempted to undercover the nature of a person's experience with a phenomenon. Qualitative methods can be used to uncover and understand what lies behind any phenomena about which little is yet known and provides the intricate details that are difficult to convey with quantitative methods (Strauss & Corbin, 1990, p. 19). Qualitative research would help me to understand and interpret how the participants in a social setting constructed the world around them, the meaning the student teachers constructed about teaching science, and how they made sense of an experience that was "lived," "felt," or "undergone" (Sherman & Webb, 1988, p. 7). Patton (1980) explains:

> [Qualitative research] is an effort to understand situations in their uniqueness as part of a particular context and the interactions there. This understanding is an end in itself, so that it is not attempting to predict what may be happening in the future necessarily but to understand the nature of that setting--what it means for participants to be in that setting, what their lives are like, what's going on for

> them, what their meanings are, what the world looks like in that particular setting--and in the analysis to be able to communicate that faithfully to others who are interested in that setting . . . the analysis strives for depth of understanding. (p. 1)

Qualitative research is an umbrella concept covering several forms of inquiry. It is used interchangeably with naturalistic inquiry, interpretive research, field study, participant observation, inductive research, case study and ethnography, and several other terms given to qualitative research. Tesch (1990), for example, lists over 40 types of qualitative research. Each type is distinguishable from the others, but all share the essential characteristics of eliciting understanding and meaning, positing the researcher as the primary instrument of data collection and analysis, data collection in the field, an inductive orientation to analysis, and richly descriptive findings (Merriam, 1998, p. 11). Merriam states that the basic or generic study, ethnography, phenomenology, grounded theory, and case study are the most widely used methods in educational research. Now the question became which typology would be best for this study?

Yin (1989) suggests looking at the question to be addressed in the study. How and why questions can best be answered through the case study method. Starting with a "how" question, I looked closely at the case study methodology. Case study is often the best choice when the variables are so embedded in the situation as to be impossible to identify ahead of time or if control over a contemporary set of events is not desired by a researcher. Yin (1994) feels the case design is particularly suited to a situation in which it is impossible to separate the phenomenon's variables from their context. Case studies include as many variables as possible and often portray their interaction over a period of time. They can describe, elicit images, and analyze situations.

I decided to use the case study methodology because it examines a specific phenomenon as a program, event, person, process, instruction, or social group (Bodgan & Biklen, 1982; Donmoyer, 1990; Lincoln & Guba, 1985; Merriam, 1998; Yin, 1994). The specificity of the focus makes it an especially good design for practical problems--for questions, situations, or puzzling occurrences arising from everyday practice. Case studies have the potential to concentrate attention on the way particular groups of people confront specific problems, taking a holistic view of the situation (Shaw, 1978, p. 2). Often case studies are selected when a goal is to achieve as full an understanding of a phenomenon as possible. "They are appropriate for intense in-depth examination of one or a few aspects of a given phonenoma that leads to insight, discovery, and interpretation rather than hypothesis testing" (Glesne & Peshkin, 1992, p. 164). Cronbach (1975) differentiates case study from other research designs by calling it "interpretation in context" (p. 123). By concentrating on a single phenomenon or entity (the case) the researcher aims to uncover the interaction of significant factors characteristic of the phenomenon.

Case studies have been variously described as a "bounded system" (Smith, 1978), an "integrated system" (Stake, 1995), or a single thing that can be "fenced in" to study (Merriam, 1998). Miles and Huberman (1994) graphically represent the method as a circle with a heart in the center. The heart is the focus of the study, while the circle "defines the edge of the case: what will not be studied" (p. 25). Stake (1995) clarifies the distinctions of a bounded system:

> The case is a specific, a complex functioning thing. The case could be a child. It could be a classroom of children. The case is one among others . . . An innovative program may be a case. But the relationship among schools, the reasons for innovative teaching or the policies of school reform are less commonly considered a case. These topics are generalities rather than specifics. (p. 2)

The boundaries must have common sense obviousness and the data collection must be finite. If there is no end, either in actuality or theoretically, to the number of people who could be interviewed or observations that could be conducted, the phenomenon is not bounded enough to qualify as a case (Merriam, 1998).

Qualitative case study data collection is usually done through interviews, observations, and collection of artifacts. Yin (1994) feels "the case study's unique strength is its ability to deal with a full variety of evidence--documents, artifacts, interviews and observations" (p. 8). Observations allow the researcher to get close to the subject of interest in the natural setting (Bromley, 1986). They enable presentation of a running account of the life in a context through the eyes and ears of the observer because they are repetitive and continue over a period of time. Observations are contextualized both in the immediate setting and in the larger contexts within which the immediate setting is framed (Walsh, Tobin, & Graue, 1993; Spindler, 1982). Interviews provide directed data collection opportunities. They are often used to provide in-depth discussion of events and the relationships that come up in observation. Interviews seek to bring meaning and understanding through dialogue and negotiation between the researcher and the researched. They can access human thoughts and feelings giving "the immediate and local meaning of actions as defined from the actor's point of view" (Erickson, 1986, p. 100). Documents address the information for a case that resides in different records. The documents can be primary material directly from the people or situation being studied or secondary material, second-hand accounts of the people or situation (Walsh et al.,1993).

The narrative of a case study resulting from the interviews, observations, and artifacts can give insight into the realities of a situation that exist in the eyes of the researcher, the individuals in the study, and the audience interpreting the study (Cresswell, 1994). Donmoyer (1990) offers that this method gives accessibility to experience where the reader might not have had the opportunity to go. We can read "through the researcher's eyes and thus see things that might not otherwise have been seen" (p. 193), experiencing the world through the eyes of the author and the subject of the study.

Case studies need to be analyzed as single, bounded units. Communicating an understanding of a case is the primary consideration when analyzing the data. Case studies provide holistic descriptions. All the episodes and text must be analyzed with correspondence or consistency within certain conditions. In addition, the behaviors, issues, and contexts need to be understood in regard to the particular case (Merriam, 1998; Stake, 1995; Yin, 1994). "For important episodes or passages of text, more time must be taken, looking them over and over again, reflecting, triangulating, being skeptical about first impressions and simple meanings" (Stake, 1995, p. 78). Oftentimes the data sources in a case present incompatible and even contradictory information, making it difficult to make sense of the data, so all the information needs to be brought together and organized for access either topically or chronologically (Yin, 1994).

Application of the Method

Having arrived at a decision to use the case study methodology, boundaries needed to be set for my case. In the discussion that follows, pseudonyms were given to the participants and sites used in the study to protect the anonymity of all participants. I defined the parameters for the study as follows: (1) Six elementary preservice teachers who would be teaching during the 1997 fall semester in the Pine School District would be used. (2) All of the student teachers would have 16-week assignments in a self-contained classroom. (3) Student teachers would be teaching in grades three to six. (4) All of the preservice teachers would have completed the mandatory block of methods courses and field experience at Evergreen University. In addition to these boundaries, I wanted the participants to have a broad range of interest in science. Now I was ready to find participants for the study and gain entry into the Pine School District.

Gaining Entrance and Securing Participants

Contacting the director of student teaching at Evergreen University to obtain a list of student teachers approved for student teaching in the fall of 1997 and their placement assignments accomplished identification of potential student teachers. I found 12 candidates who fit the criteria identified for the study. Having established that there were sufficient candidates for the study, I turned my attention to gaining access to the site. I needed to obtain permission from the "gatekeepers" (Glesne & Peshkin, 1992). Having been advised that the first person I needed to obtain permission from was an assistant superintendent for the Pine School District, I made an appointment with him, but that meeting never took place because a crisis delayed access to the site for over three months. Scheduling another appointment with the assistant superintendent was difficult because a myriad of problems faced the school district. I sent him a letter explaining my study and listing my connections to the Pine School District since moving to the area, along with a copy of my research proposal. Within a week, I was asked to submit a list of potential candidates for the study and their student teaching assignments.

I decided to deliver this information personally in hopes that I might be able to talk to the assistant superintendent. Instead, I was informed by the secretary that my proposal would be presented at the next elementary principals' meeting, three weeks away. The assistant superintendent telephoned me after that meeting and told me the principals had given permission to conduct my study in the Pine School District, but it had been decided that I should try to work in only two schools, which had a total of six student teachers assigned in the upper grades. Concern was expressed that not all of the student teachers would be willing to participate, and we agreed that I would contact the six student teachers from the two approved schools to see if I needed to reach other schools. It was also learned that three other principals had given tentative agreement for me to enter their buildings if necessary, but final approval would be needed.

I telephoned the six student teachers assigned to the two schools and explained my research study to them. The first two student teachers I called from School A were enthusiastic and readily agreed to part be of the study. The other student teacher was interested but wanted to think about it for a week. She reminded me that she really did not like science and thought she might not be a good person for the study. In the meantime, I was trying to make telephone contact with the three student teachers from School B. Again, two of them readily agreed and were excited that I had considered them for the study. When I finally made contact with the third, she informed me that her assignment had been changed. Shortly thereafter, the undecided preservice teacher told me that she would not be part of the study. I contacted the assistant superintendent, explained the situation, and asked him if he would contact the other principals who had tentatively agreed to my working in their schools. I was given permission to contact the student teachers from two other elementary schools, but it was now the second week of August, and I had difficulty reaching the student teachers. When I did make contact, two of them agreed to be part of the study.

School was scheduled to start in two weeks, so I began to arrange times for the first set of interviews. When I contacted one of the student teachers from School B, she told me that she had just talked to her cooperating teacher and learned that she would not be teaching science because the sixth grade at that school was departmentalized, and her assignment was social studies. Luckily, I was able to make contact with another student teacher from School C, who was hesitant, but after we had talked for a short time decided to give it a try.

The participants in the study were all elementary majors completing the final year of their teacher preparation program at Evergreen University. All of the participants had acquired either a minor or concentration in their area of interest. Three participants held a minor in special education, one had a minor in bilingual education, and one had pursued an area of concentration in math. One participant had a liberal arts degree with a minor in biology from another college and was completing the requirements for her teaching certification. The group was composed of five females and one male, 21 to 25 years of age. Three of the participants were assigned to sixth-grade classrooms for student teaching while the other three were in third-, fourth-, and fifth-grade classrooms.

All of the participants were completing the elementary education program at Evergreen University. The program at Evergreen University supports a child-centered, constructivist philosophy. Elementary education majors must take ten semester hours of science courses in the earth, life, and physical sciences including four semester hours of a lab science. They may complete their science requirement either by general education courses or by taking the science courses offered through the college of education. Elementary education majors complete a block of methods courses, taken with a cohort group, in one semester. An accompanying field experience is included. Elementary education majors at Evergreen University are required to have completed all methods courses prior to their student teaching. Additional courses in math and science that combine content and pedagogy are also offered in the college of education.

Data Gathering

Participants were asked to sign the letter of consent reproduced in the Appendix before their first interviews and to retain copies for their records. Each was assured that pseudonyms would be used and their identity would be protected. They were also informed that they could withdraw from the study at any time. Most of the interviews were conducted at Evergreen University, the preference of the participants. Rochelle found it difficult to come to the university, so her interviews were conducted in the classroom after her cooperating teacher had left for the day. Occasionally, some of participants found it inconvenient to come to the university, so their interviews were conducted in their classrooms.

Five interviews were conducted with each participant between late August and the first week of December. Most of the interviews were between 45 minutes and one hour in length. All of the interviews were tape recorded with the approval of the participants and transcribed. The interval between the first and second interview was five weeks because I wanted to wait until the participants were teaching science. At the time of the second set of interviews, some of the participants had not taught any science yet. I kept in weekly contact with the participants either by telephone or by visiting their classrooms. Notes were kept on most of these conversations.

The purpose of the interviews was to find out how the student teachers were making sense of teaching science in the classroom. I viewed the interview as a conversation with a purpose that went beyond the spontaneous exchange in everyday conversation to careful questioning and listening (Kvale, 1996), an attempt to find out what was "in and on someone else's mind" (Patton, 1990, p. 278). Usually the interviews began as a casual conversation about the events of the student teacher's day and ended in the same manner. I employed a semi-structured interview technique using some preprepared questions to guide the interview. Before every interview, I prepared an interview guide of questions that might be explored or issues to be explained. Neither the wording nor the order was determined ahead of time, enabling me to respond to the situation at hand or to new topics that arose. The interview guides helped me, however, to make sure that all topics were covered, but gave me the freedom to build conversations that could explore, probe, and ask questions about a particular subject (Patton, 1980). Since most of the interviews took place at the end of the student teacher's school day, they had a tendency to circle around the event or events foremost in the participants' minds or, if the participants were tired, they usually were not interested in exploring topics in depth, so the guide helped to keep the interview moving.

Field observations were also used to collect data. I visited each classroom a minimum of seven times after each student teacher had begun teaching science. I visited Wendy's and Tammy's classrooms more because they began teaching science earlier than the other student teachers in the study. Before entering any of the classrooms to observe, I stopped by and introduced myself to the cooperating teachers and explained my study to them. I asked them to sign the consent form reproduced in the Appendix giving me permission to enter the room to observe and gave them copies for their records. All of the cooperating teachers were aware of my study before I talked to them because the student teachers had told them about it. All of the cooperating teachers were willing to have me observe in their rooms, although two of them sought reassurances that I would not at any time observe them teaching science.

I observed only at the times science was being taught by the student teachers. Thus, the student teachers usually knew beforehand that I was coming, but most of them were not sure exactly when they would be teaching science. At first some told me to come any day at science time during the weeks they were scheduled to teach it, but often that did not work. I would arrive only to find that they were not having science that day. Observations were sporadic because science was not taught with any consistency in most of the classrooms. Most of my observations were 30 minutes in length. If the lesson went longer, I usually stayed until it was completed. I took field notes while I was in the classroom and wrote full notes of the observation during that same day. The observations provided knowledge of the context as well as specific incidents and behaviors that were used as reference points for the subsequent interviews. During these observations, I learned to pay special attention to "some things which others ordinarily would give only passing attention to" (Wolcott, 1992). I added observer comments to the field notes about what I had seen or heard, my reactions, hunches, and initial interpretations. I kept a journal of my observations and comments and referred to them when planning my interviews.

My role as a participant observer varied from classroom to classroom. I tried to maintain the role of the unobtrusive observer (Marshall & Rossman, 1995) in most rooms. This was harder if, as sometimes happened, the student teacher would ask me a question during the lesson, usually seeking clarification of a concept. At first, the students ignored my presence, but as I came more often, some of them would come over and talk to me or ask me to help them with some work. If the students were working in groups, I would get up and wander around the room to find out what was happening. It was not unusual for the students to tell me what they were doing or ask me questions about the activity if I stood close to them. This fit into what Merriam (1998) found:

> As a researcher gains familiarity with the phenomenon being studied, the mix of participation and observation is likely to change. The researcher might begin as a spectator and gradually become involved in the activities being observed. In other situations an investigator might decide to join a group to see what it is actually like to be a participant and then gradually withdraw, eventually assuming the role of the interested observer. (p. 102)

Artifacts were collected from some of the student teachers in the study. Some chose not to share anything; others were willing but forgot to give artifacts to me, and others always had documents from their science teaching they wanted to share. The artifacts included lesson plans, entries from student teaching journals, brief reflections on lessons, and student work that was the end product of a lesson they were excited about. Two of the student teachers shared science autobiographies that they had written for their science methods course. Some of them had never written a science autobiography and preferred to do it as part of an interview. I found some of the documents were not useful but others offered a "behind the scenes" look at lessons and related student responses to activities I had not observed. These artifacts often spurred ideas for interview questions.

Understanding the Data

In qualitative research, data analysis is done simultaneously with data collection to focus and shape the study as it proceeds. Data analysis involves organizing what has been seen, heard, and read so that the researcher can make sense of what has been learned (Glesne & Peshkin, 1992; Marshall & Rossman, 1996; Merriam, 1998; Miles and

Huberman, 1994). Coding, a systematic way of developing and refining interpretations, is usually the first step in data analysis of qualitative research (Taylor & Bodgan, 1984). It assigns shorthand designations to data to identify concepts, central ideas, or themes that reveal information relevant to the study and reflects what the reader sees in the data (Merriam, 1998). Coding can illuminate significant classes of things, persons, events, and properties that characterize them and identify many individual examples within them (Marshall & Rossman, 1996).

Data analysis began with coding as soon as I had transcribed the initial set of participant interviews. My initial code sections ranged from parts of sentences to several paragraphs. I coded everything following Glesne and Peshkin's (1992) advice to be "overgenerous so as not to foreclose any opportunity to learn from the field by prematurely settling on what is or is not relevant to you" (p. 134). This was only the first level of coding: the identification of information about the data. The next level would be to interpret the constructs of the data (Merriam, 1998, p. 164). After coding several interviews, I read through all of them again, looked at all the codes, thought about how some of them linked together, and collapsed some into larger chunks and renamed them. Some of the data fit into two or more coding categories, so I began a process of multicoding (Strauss & Corbin, 1990). Coding continued as the interviews were transcribed and observations were expanded into full field notes. I tried to add, collapse, expand, and redefine the categories as I worked through the data (Marshall & Rossman, 1996).

I read and reread the data to become more familiar with it and to keep a focus on the study, especially during the periods when transcribing of the interviews became slow. This helped to keep the people, events, and quotes sifting continuously in my mind (Marshall & Rossman, 1996). I started making notes and asking questions, gaining insight on what I was seeing in the field and identifying puzzles to ponder (LeCompte & Preissle, 1993). This proved to be a helpful tool as I prepared for the interviews and observations.

The Ethnograph computer program (Seidel, Friese, & Leonard, 1995) was used to manage the data. I liked to code all the transcribed interviews and observations on paper before entering them into the Ethnograph program. The program proved to be a useful tool for me. It helped to refine my codes as they were entered and to construct a code book that listed all the codes currently in use and their frequency. After three interviews, I had close to 100 codes, many of them with only one frequency. A quick review of the codes revealed that several terms were being used to represent the same concept. More importantly, I realized that I was still coding small bits of information and focusing on the concrete data instead of looking for the abstractions. The program was used to bring a common name to the same concept. Then I recoded the interviews, looking for concepts that aided in my interpretation of the words and acts of the participants. I found that if I reread the observation or interview in its entirety and looked over the codes, I often saw how the data could be further collapsed. The data that appeared to fit into more than one code was multi-coded and subcodes within a main code were indicated. I referred to Lincoln and Guba's (1981) guidelines for making categories both comprehensive and illuminating. I began to look for dimensions that were important as indicated by the number of people who mentioned them or the frequency with which they sometimes arose from the data, findings, areas of uniqueness in the data, and areas of inquiry that are not usually recognized. When all the data had been coded, a copy of each interivew, observation, and document from the Ethnograph program was printed. Then I used the program to locate all the data chunks for each code, printed them, and marked the disconfirming evidence within each code with a colored marker. I was ready to begin the final analysis of the data.

With the data collection completed, I began to analyze the data, using the codes for "explanation building" (Yin, 1989) as I looked for emergent patterns and themes. I noted the regularities in the setting or people chosen for the study. I checked to make sure the codes were internally consistent but distinct from one another as I tried to identify the salient grounded categories of meaning held by the participants in the setting (Marshall & Rossman, 1996; Patton, 1990). I compared and contrasted the data, searched for other plausible explanations and identified them, established linkages and relationships, and speculated in an attempt to find the themes and patterns of the case. As patterns began to emerge from the codes, I searched for other plausible explanations for the data and identified them. Everything began to fit together like a jigsaw puzzle.

> The edge pieces are located first and assembled to provide a frame of reference. Then attention is devoted to those more striking aspects of the puzzle picture that can be identified readily from the mass of puzzle pieces and assembled separately. The assembled parts are placed in their general position within the frame and gradually the connecting pieces are added until no holes remain . . . a whole

> phenomenon is divided into its components and then reassembled under various new rubrics. (LeCompte & Preissle, 1993, p. 237)

The puzzle picture now had 27 codes or pieces that needed to be rearranged and linked with each other to form a picture. These codes were cooperating teacher, models, time, textbook, schedule, advice, constraints, student response, style, fun, concern, love, unsure, manage, groups, relate, assess, tell, experiment, think, teach, preparation, questions, adapt, hands on, and reality. Each code contained characteristics or attributes of data related to the code name, the small details on each piece of the puzzle.

The codes were arranged and rearranged until connections were found that linked some of them together into larger sections or categories. Five categories were formed from the codes: Influence, Feelings, Reality, Strategy and Science. One category or part of the puzzle went together easily. The code grouping of cooperating teacher, models, time, schedule, and student response connected together to form the category of Influences. Constraints and style were later added to Influences when further analysis revealed that they held many attributes common to the category. Some codes, such as cooperating teacher, schedule, and time, seemed to fit into several categories. These codes seemed to be like the odd shaped pieces of a puzzle that are used to link several pieces together.

After the five categories were formed, interlinking ideas among them were sought as a means of disclosing the story found in the picture when all the puzzle pieces were joined together. The categories were compared and contrasted to find the repeated relationships among them. The patterns or themes that connected all the data in the puzzle pieces together emerged after several comparisons of the categories were made. Two themes connected to make the picture complete were: (1) personal and professional career influences and (2) constant adjustment of teaching strategies. The story found in the picture could now be told. Two assertions or conclusions were formulated based on the themes or patterns of the study. These assertions or statements of relationships made from the themes are presented with supporting evidence in Chapter Five. A diagram that illustrates how the puzzle pieces fit together to form the picture of the study is found on the following page.

Triangulation was achieved in this study by using different data collection techniques: interviews, observations, and collection of artifacts. Use of different sources of information can help minimize the influences of researcher bias in a study (Glesne & Peshkin, 1992). Further triangulation was sought by interviewing the cooperating teachers after the student teachers were no longer assigned to their classrooms and by informal conversations with the student teachers' supervisors from Evergreen University, both with the agreement of the main participants in the study. I tested the data gained from each source of information against another to strip away alternative explanations. The different information sources were used to test the quality of the information and the person sharing it, to understand more completely the part a participant played in the setting, and to put the entire situation into perspective (Fetterman, 1989, p. 89).

CODES	CATEGORIES
Cooperating Teacher Models Time Textbook Schedule Advice Constraints Student Response Style	Influence
Fun Concern Love Reality Unsure	Feelings
Manage Time Groups Textbook Cooperating Teacher Relate Constraint Assess Unsure Schedule	Reality
Tell Experiment Assess Think Style Model Teach Preparation Questions Concern Adapt Relate Schedule Time Hands-on Textbook Group Constraint	Strategy
Preparation Model Cooperating Teacher Schedule Hands-on Manage Teach Group Reality Relate Concern	Science

THEMES & ASSERTIONS

Personal & Professional Career Influences

Student teachers' views of science are Influenced by personal memories as well as By non-professional and professional mentors:

- Personal images influence the act of teaching science.
- Personal mentors can support science teaching.
- Cooperating teachers have positive and negative influences on science teaching.
- Scheduling is one way cooperating teachers influence the teaching of science.

Constant Adjustment to Teaching Strategies

Student teachers develop their personal pedagogy as a result of their science teaching experiences.

- The student teachers were surprised by the form and content of the science curriculum.
- Student teachers interact differently with the science curriculum.
- Group management affects the efficiency of hands on science.
- Student response affects science teaching.

Summary

This chapter described the background of the study and the rationale for the use of the case study methodology to learn how elementary preservice teachers make meaning of science teaching during the student teaching experience. The chapter also included information regarding entrance, identification of participants, and data collection and diagram analysis. Interviewing and observing the student teachers were primary sources of data, which consisted of transcripts of the interviews, field notes from the observations, and artifacts from science lessons. Analysis of the data revealed 27 codes, which were grouped into five categories. Two themes emerged from the categories from which two assertions were advanced.

CHAPTER IV

PORTRAITS

This chapter presents portraits of each of the informants. The goal is to paint a picture of each informant so he/she will be credible in the analysis that follows. The portraits reveal personal characteristics and teaching behaviors that relate to science teaching during the student teaching experience.

Sam

Sam's hesitancy about participating in the study was evident during our first meeting. He was worried that it might jeopardize his student teaching, especially if the principal did not approve. When he entered the room for the initial interview, his first words were "I hope this doesn't take long. I don't think I have time for this." Then he told me I was to call the principal of the school where he was student teaching before I could interview him, or he could not be part of the study. He said, "He wants to know what this is all about. He doesn't want you to interfere with my student teaching." Since I had previously secured permission, I assumed a miscommunication had resulted due to the confusion surrounding the beginning of a school year and Sam's uncertainty of what the study actually involved. I showed Sam the letter the principal had signed allowing me to enter his building to observe student teachers. Sam and I discussed the study in detail, and he read the contract carefully before he signed it. He was satisfied that he could drop out if it took time away from his student teaching. Sam did not want anything to interfere with completing the last requirement for graduation. He stated, "To get my degree finally. That influences me a lot to achieve that degree. Nobody in my family has one except for my uncle so I want that degree."

During the next few weeks, Sam still seemed reluctant to participate in the study. I had talked to his cooperating teacher, and she had signed the consent form for me to enter the classroom and was supportive of Sam's participation. I stopped by the classroom occasionally to check how things were going and when he might begin to teach science. Yet, Sam put off the second interview, citing various excuses. One day as I was visiting with Sam and his cooperating teacher, I discovered that they had never actually talked about his participation, so he did not know if it was an issue for her. After the cooperating teacher had expressed her support, Sam asked her if she thought he could be interviewed after school that week. She said that it was fine to do it right after school or any time he was not busy with the students. Immediately after that, he asked if I could come the next day.

During our second interview, I discovered Sam's reluctance was based on his not being sure of his cooperating teacher's approval of him doing something extra during his student teaching and his nervousness about my observing him teaching science. He thought I would be evaluating his science teaching, and he was concerned about his background knowledge in science saying, "During my field experiences, I discovered that some of the kids in the classroom knew more than I did about science. I decided I better get hitting the books and learn some more." I explained exactly what I would be doing during an observation and reviewed the purpose of the study. I reminded him he could drop out of the study at any time if my observations made him too uncomfortable. The subject never arose again.

Sam focused on his feeling of inadequacy about classroom management and how he didn't feel he was teaching just like his cooperating teacher during the second interview:

> . . . I started asking her [cooperating teacher], "What kind of things are you going to say so I can say almost the same thing?" . . . I would say, "This is what we are going to do tomorrow, what would you do differently?" She would give me some suggestions and sometimes she would say, "That's great. That's a new one, I never thought of that. Or try this and see if it works that way."

Sam started teaching science almost two months into the school term. In this classroom, science was alternated with social studies during the school year, and the cooperating teacher began the school year with a unit in social studies. Sam decided to teach his first science unit on bones at the suggestion of his cooperating teacher and the third-grade teacher next door. He never actually planned a unit on bones. Instead, he just started gathering materials and worksheets from teacher magazines, the Internet, and other teachers: "I am going day by day, trying to find something new every day." Sam added,

> I wish there was more stuff, more that would say, "This is what kids can learn if they learn this about bones.' And then here are more things I haven't found out about yet. What they should learn first, second, third. That is the most difficult. I am, like every week, I am thinking "What can I do the next day? What can I do

> this day?" I don't know because I didn't make up a unit before. I like the freedom cause you don't have to follow along, but when you run out of things to do, you can't think of something, you can't fall back on something.

He did not get any direction from the cooperating teacher as she had never taught about bones before and was not familiar with the material. However, she did help him locate resources to use.

Sam's primary teaching strategy during the bones unit was to place a copy of the student worksheet on the overhead, call on students to read parts of it, ask questions about the information on the worksheet, and spell all terms together before everyone wrote the word on the paper. Sam usually had the students work together as a whole before giving another worksheet to do independently. When the students worked independently, Sam constantly moved around the room and provided individual help.

During the last part of the bones unit, many activities centered around art, which Sam referred to as "hands on activities." Several times, he talked about trying experiments: "I want to do an experiment with the chicken bone and vinegar, but I don't know where to get chicken bones." He did try a demonstration experiment at the end of the unit. He showed the students the connection between the size of their foot and their radius, telling them what they would learn and then measuring some of the students' radii and their feet.

Sam was excited about his bones unit and loved the students' reactions to bones. It motivated him to find more things. He said, "The way they are fascinated. They didn't know about, just knowing that they learned. Even me, I learned a lot already . . ." Sam thought science was different to teach than the other subjects, commenting,

> You have to know more background, more background information, cause you don't know what is going to come up. Yeah, especially when they tell me these facts that they have learned that I don't know if they learned it or not. And I don't know the answer to them either. When you are teaching math or reading you know the answers, but science, like I already told them, I check on some things cause I don't want them to think I am not doing my job.

After Sam taught about the bones, there was about a three-week gap before science was taught again. This time the cooperating teacher decided that she would try alternating science and social studies by days instead of units. Three days a week were scheduled for science or social studies with art and other activities scheduled for the other two days. Within this format, science was usually taught one day. During the last four weeks of his student teaching, Sam was able to teach science only three times. He did not feel that the long gap between lessons affected the students' learning. He said, "The students will ask about when they are going to have science again, especially if they had done something fun before. They remember most of what was taught but are disappointed if the lesson, if it isn't fun for them."

Sam encountered a totally different experience in teaching science when he was given a unit on rocks to teach from the district science curriculum:

> I knew it was coming, but when it got to me it was like "What do you do now?" For some reason, it was so much more difficult to teach rocks than bones. He laughed. I know more about bones than rocks. I didn't have as many fun things

> to do with them like I wanted to. It was more "Read this and do this. Let's try an activity and hope it works." With the other one, the bones one, it was, "Let's do this, yeah, yeah." But with the rocks—go slow. . . If I had to teach rocks, I wouldn't use that kit. I would find something on my own, I guess, or find a bunch of rocks or rock books and see what kind of activities they would have. Some of the activities weren't worth my time at all.

One day when I was in the classroom observing, it was evident that Sam was struggling with teaching the rock unit. I had been there only ten minutes when he told the class to put away their books. He was giving them some free time. When asked later about this lesson, he said,

> I was having trouble just reading out of those books in science, cause I didn't know much about rocks anyway, and I just felt guilty with the kids making them read some of the days. It gets so boring and repetitious for the kids. So I would say, "Let's do whatever. . . " I thought I was going to do good, cause I just got done with bones. Then with rocks, I thought I was just going to get better and better. And then I had like a big roadblock when I got that kit. I stayed at a pace.

He did have one experience with the rocks that pleased him. He gave the children a piece of clay and told them to shape it into something they knew was made of rocks. He had them draw blueprints of the objects and required he approve them before they could play with the clay. He explained, "I didn't want them to just start playing with it. I wanted them to play with it but I wanted them to have an idea of what they were going to make before they started. They made bridges and buildings and pencil holders."

At the end of student teaching, Sam ranked science as his fourth favorite subject to teach based on his student teaching experience. Spelling, math, and reading ranked above it. With a laugh, he said that he would have ranked art at the top except I didn't have that in the pile of subject cards.

Sam came into the last interview with a smile on his face, excited to talk. He had picked up his cap and gown and was telling me about the fuss his family was making over his graduation. He felt his student teaching was successful. He knew that teaching was something he wanted to do the rest of his life, saying, "I like everything. It's fun."

Angela

Angela, a soft spoken, neatly dressed student teacher, wasted no time during the first interview in telling me her views of science in elementary school. She said, "I hated science. I don't know. I think it was when I was younger, it was all from the book and we had worksheets, worksheets—all kinds of worksheets. We never, you know, never experienced anything."

She began to view science differently in the fifth grade when the teacher provided some outdoor hands on activities but added, "We still had worksheets though." A transition in her thinking about science occurred in the seventh grade when she had a teacher who tried to make science fun. By high school, she professed to love science. She took all AP science courses in high school. She stated,

> I took classes that were probably more challenging for me, but I learned more, and taking things that were more challenging, I knew I had to devote myself more

> and work harder. I kinda realized that science wasn't all that bad and started to enjoy it.

Science needed to have a purpose for her: "Why are we doing this experiment? How does it relate to what I am doing?" Making learning relevant to her students was a major part of her philosophy about teaching. She verbalized this clearly during our first interview. Angela explained,

> The thing I want the most to do is, whenever I teach a lesson, have some aspect where the students can see where or how it relates to them or how . . . they can at least see why they are doing what they are doing or how it is going to help them.

Angela was able to put that philosophy into practice early in her student teaching. She came to an interview very excited about the social studies lesson she had taught that day. The class had been reading about social classes in Egypt. She could see they did not understand, so she decided to have them write what they thought it would be like to live in one of the social classes in Mesopotamia: "It was neat. They got the point. They learn through experience. They could tell how they felt and what it would be like within one of those classes."

Making science relevant to her students' lives proved to be more difficult for Angela. When she took over the science teaching, her sixth-grade class was studying about simple organisms. She struggled with the content she was teaching even though she remembered studying it during high school and college. It was not a topic she had related to or enjoyed. Every time she studied it during her own school days, she remembered thinking, "Oh, we are doing *this* again." She stated,

> A lot of it was new to me. I remember learning about this stuff before, but just having to remember the parts of a cell and how plant cells and animal cells are different. It was kinda like relearning it and then learning how to teach it to them.

She was happy the students seemed to like it. "I like how the students were really excited . . . which I didn't think they would be."

Although Angela was not excited about the topic she had been assigned to teach, she tried to find ways to make it meaningful to her students. She studied the material and practiced the demonstration experiments several times before teaching the lessons to the class. Her basic approach for teaching about organisms was reading out of the textbook, discussing the material, repeating the information to the class, having the class make diagrams of every organism in the book, and doing some demonstration experiments. She explained, "I based a lot of it just on when I watched my teacher teach science because the way the book is laid out . . . it's just really choppy." She tried several demonstration experiments on protists with an overhead microscope that never worked properly. She became frustrated and anxious when she was unable to provide the students with an opportunity to see the organisms. In addition, she did not feel comfortable using microscopes. She explained,

> The microscope stuff is the part I am most afraid of. When we used that overhead microscope, there was like they were supposed to see spores and there were a few that I could see, but the lighting is so bad on that and there is not really a whole lot that they can see. They didn't see everything they should have. The big

> [microscope] was the only one I had. When they have their microscopes to look at . . . their observations are better.

The inadequacy of the microscope forced her to tell the students what they should see and have them draw more diagrams out of the book.

Angela struggled throughout the unit on organisms to find ways to make the material meaningful to herself so she could help make it relevant to her students. One day after reviewing the mechanisms protists used for movement, and realizing that the students still had not grasped the concept, an idea came to her that perhaps if they wrote a story based on the question, "If you were a protist, would you choose to have cilia, flagella, or pseudopods?," they would begin to relate it to the world they could see. Angela said, "I like it when I am teaching science when something will click in my head and I will remember something that I did when I learned that." She was eager to relate to me at our next meeting how the students made a connection to their own world when they wrote their stories. The students assumed the roles of different animals, fish, and insects that utilized some of the same mechanisms as protists to move and explained their choices.

Angela was finally able to make protists real to both herself and her students during a lesson in which the students viewed them through microscopes in small groups. At the beginning of the lesson, Angela stood at the front of the room preparing slides and occasionally helped a group with the microscope. She let the cooperating teacher take the lead in helping the students find the protists under the microscopes. The students began to get excited when they saw the organisms and called her over to look, pointing out various parts they could remember from the book. By the end of the lesson, Angela was going around to the groups, asking them questions, looking in their microscopes, pointing out things she discovered, and allowing the students to make their own slides. She observed,

> Until they can actually see it, I don't think they realized how microscopic the things really are. Especially when we made the drawings. I don't think they really had a clue how big or small they really were until they saw them under a microscope.

When Angela was going to teach about fungi, her cooperating teacher suggested that she use mushrooms to help the students understand spores. Although she had eaten mushrooms, she had never looked closely at one or even touched one. She told me that she had never even thought about them in relation to fungi before her cooperating teacher suggested it. Angela did not enjoy touching and exploring the mushrooms, but it helped her. She had the students take apart mushrooms and examine them with magnifying glasses. She related that she knew the students had really understood about spores from their later references to the examining of the mushrooms when they reviewed spores in class. She lamented that she had no time to do a mold experiment from her science methods class from which the students might see how spores grew and multiplied. She commented, "That was really interesting to me. I understood more about mold after that."

Angela felt that the number of days science was taught and their placement in the class schedule influenced her teaching. Science was taught on Monday, Tuesday, and

Wednesday, during the last period of the day. On two of those days, science time was usually cut by five to ten minutes because the students returned late from physical education. The three-day schedule made continuity of the lessons difficult. Angela explained,

> The way the book was set up, there would be an experiment almost every other page. It would only take like 15 minutes to discuss what was on the page, so you would try and get as many experiments in as you could in that three-day period so that when it came to move on in the reading section the next week, you wouldn't have the experiments to finish up. The experiments would be so rushed when you had only 30 minutes. You might have two sections left to talk about, but you know you can't cover it in three days so you have to extend it or slow down the pace cause you need more than three days to talk about it, and you wouldn't want to have the test on Monday after they haven't talked about it for two days. It was difficult. We spent a lot of time reviewing science. . . It's not like you could read one day about all the stuff, do an activity, and the next day do an experiment. It was mainly following along in the book and reading the experiments.

Angela felt the structure and environment of the classroom restricted her overall teaching, not affording her the opportunity to explore different teaching approaches. She choked up, and tears came into her eyes, when trying to express her feelings, saying,

> I didn't feel comfortable with the way this classroom was run and I didn't like it. . . . It just wasn't how I would want to do it. Who cares if one day you switch science. . . or if class goes over a couple of minutes? There were so many

> things I wanted to do. There were probably a lot of things I didn't get to try because of the kids too. . . I know how I did most of my teaching, but I don't feel that is my style of teaching. I really didn't want to do it that way. But most of the stuff I did was reading out of the book or using the overhead. The way I would like to do it is more I see myself doing it as . . . kinda being a learner myself.

Angela's experience with teaching science was limited to the unit on protists. She was looking forward to teaching the next unit on forces and motion, but her cooperating teacher decided to teach it, although she did provide Angela the opportunity to help with some of the activities.

Angela clearly identified social studies as her favorite subject to teach but felt that her experiences with science teaching during student teaching were beneficial:

> I feel more comfortable teaching science now that I have actually done it. I think that it would be the most time consuming for me as far as planning goes, cause everything else I seem to have a pretty firm grasp on. The more I taught it, the more willing I was to try new things.

Her philosophy that students must be able to relate what they are learning from a book to their immediate world was reinforced during her student teaching. She said,

> I think that it helps them to relate it more to their everyday life. Instead of saying, "These are viruses. This is the definition, and these are examples of them." It probably wouldn't have meant so much. . . . Science is all around us, all the time. I want students to learn that. Even learning about an atom is something that

is somewhere in their lives. It will be important to them.

Angela has concerns about teaching science in her own classroom. Her worries focus on "doing all the stuff I want to do and not being afraid of science. Trying out different experiments. Not being so worried about it, you know, about not going well."

Rochelle

Rochelle, a talkative, outgoing, child-centered student teacher, was looking forward to teaching science in her sixth-grade classroom, but almost missed the opportunity. It was one of three subjects added to her teaching load only three weeks before the end of her student teaching experience. When she was assigned to teach science, Rochelle made sure she taught a science lesson every day. Just as she began, however, her 9 month old baby came down with chicken pox. Rochelle's energy and organization seemed to ebb and flow during this time, but her creativity remained ever present.

Rochelle taught about oceans, a unit the cooperating teacher had already started. It was not a topic with which she was familiar, so she looked for activities and experiments that would spark students' interest and be fun to teach. She created ocean boxes to motivate the students to find out more about the ocean. She divided the class into pairs and made for each pair a box filled with small pieces of neutral colored paper into which she placed a camouflaged piece of paper with a name of an ocean related term, such as the name of a sea creature or oceanographer for the students to identify, research, and write down five facts learned about the topic. Every day Rochelle put different words related to the same topic in the boxes, and the class shared and compared their findings during science class.

Rochelle's first approach to science teaching was to read and discuss the information in the book. Before long, she became bored and decided she needed to get the students more actively involved in their learning. She decided to have the students do an experiment to discover how a whale keeps warm in the cold ocean water. Working in groups, the students were to add snow to a half filled bucket of water and then figure out how to keep their hand warm in the cold water. The only item they were given was a baggie for each member of the group. Before they could begin, the students were asked to make a prediction using descriptive words of how it would feel when they put their hands in the icy water. All general instructions for obtaining the materials and writing the prediction were written on the chart paper in the front of the room, but the procedure for doing the experiment was not given. Rochelle told the students they were to find out how they could keep their hand warm in the water, and she wouldn't tell them how to do it. She then gave each student in the class a baggie. The students explored with the baggies and the water for about ten minutes before Rochelle brought them back together to discuss their findings. Each group shared what they had tried, what they had learned and what they were still curious about. Rochelle then introduced shortening as another tool for exploration. Again, she told them to make a prediction and talk together how they would test it. Following this, Rochelle facilitated a discussion, letting it continue until all ideas had been discussed and explored. She encouraged the students to go home and try other ways to keep their hand warm in icy water and bring their findings to class the next day.

Rochelle had to make several adaptations to the lesson before and during the lesson. She explained, "I had planned on bringing ice. So I thought, 'What am I going to do?' Then, 'O.K., Snow! We will get a couple of buckets of snow.'" Rochelle was worried that she would not have enough shortening for the experiment: "I had my husband go to the store, and he got me a small Crisco instead of a large one. It worked out and I figured it out." When the students went to clean the shortening off their hands, they discovered that there wasn't any soap at the sink. While discussing how to clean their hands, the students began to observe that their hands felt soft after they had rubbed shortening on them, and this led into brainstorming ideas why this happened.

Rochelle felt that the students really enjoyed science. She thought that some of them were not as used to critical thinking as others, but that this is natural in any classroom. She said, "They love doing hands on stuff. It really helps them."

Rochelle found that science was not harder to teach than other subject in the curriculum, but was harder for the students to learn. She elaborated, "They have to observe more and ask more questions of themselves. They have to get down and manipulate, and if this doesn't work, let's test it and try it again and form a new hypothesis. That is harder for them." She added,

> I tell them to think like a scientist and what they do and our role. They just look at something and say "Yep, this is what it is." They have to test it. They have to test it again. They have to test it again to make sure, you know, so it is important

that we collect a wide variety of data to look at and analyze and not just one piece of data.

Rochelle felt that both the traditional teaching and hands on teaching are needed in science. She explained, "They learn from both of them. Some can't draw the connection when you do hands on and need to read and discuss. Others learn more from the penguin-type thing than the traditional." She enjoyed doing the hands on stuff, but was not satisfied with an experiment she did on the water cycle that was too directed, and did not give the students enough room for exploration:

> That's o.k. if you are just trying to review or emphasize something. For what I'm trying to do, it wasn't o.k. because I was trying to explore, to have them make it an exploration, yet it was too pointed and it just didn't work. The main idea was very simple.

Rochelle remembered being bored in science classes in school and does not want to do that to her students. She elaborated,

> Here I am reading about electricity and looking at those dorky pictures in the textbook [Rochelle makes snoring sounds to emphasize her point]. I did it, but it wasn't fun, but you don't have to do that because I want them to know that . . . science is [what] these chemists and whatever they are manipulating. They are using their hands. It is very hands on. You know paleontologists are using their hands. So I think they should be using their hands too. I want to make sure that they know what the purpose of this is, what the purpose of them learning this is. I want them to know that it is important for them . . . to motivate them to learn this.

Although Rochelle thought teaching science was fun, math was clearly her favorite subject. Rochelle has a concentration in math and was happy that she had been allowed to teach it throughout the entire student teaching experience. She also enjoys writing and is in the process of writing a children's book. Rochelle feels that math and writing should be integrated into other subjects and made an effort to include them in every science lesson she taught.

Tammy

Tammy entered student teaching with excitement and enthusiasm, feelings that remained throughout her experience. She came to every interview eager to share what she was doing: "I can really tell I am excited about teaching cause I love to talk about it. I do. I feel like I could talk about it forever." She usually came into the interview with a flourish, sat down, and immediately started talking about her day. During the first weeks, many times she commented on how exhausting and tiring teaching could be: "Tiring! Tiring! Tiring! By the end of the day, very tiring. But it is worth it. Worth every penny!"

The students motivated her. She explained,

> They are the funniest people I have ever seen in my life. We got kids that do the strangest things. They are the craziest people. That is what keeps it interesting. Everyday I walk in here and you just don't know what is going to happen.

As Tammy moved into the teacher role, her physical appearance changed. Gone was the girl with the swinging ponytail, and in its place was a haircut that made her look more mature. However, the physical change did not dilute any of the energy that always seemed to radiate from her.

Tammy's student teaching assignment was in a sixth-grade departmentalized setting. In the morning, math, spelling, and language arts were taught in a self-contained classroom setting, but in the afternoon Tammy's cooperating teacher taught science to all three sections of the sixth grade. During our first interview, Tammy was excited by the prospect of teaching science all afternoon: "Science is fun because I am sure they see things the same as you know I did. I was wondering, 'What the heck? Why we had . . . ? Why are the antennas sticking out?'" Tammy anticipated that science would be taught using a hands on approach with many experiments simply because her cooperating teacher had volunteered to teach the science for the sixth grade. Tammy did not want to do things in science that she thought would bore either herself or the students. She stated, "I don't think I would ever give worksheets or anything like that. That is boring!" She soon discovered that "they do boring stuff. Paper and pencil. Things on the overhead. But nothing too exciting. Right out of the work[book]. Worksheets, questions."

When Tammy began to teach science, she chose to include experiments in her first science lessons. The first time Tammy taught science, she shared the teaching with her cooperating teacher. She conducted a buoyancy demonstration, which she reported went well: "It was just one we did a million times with the salt water and the plain water and the boiled egg." For the first lesson she taught on her own, she did a hands on experiment on ocean currents:

> I just thought to start right off the bat with an experiment cause it is more fun for them to do hands on, to see everything, whatever, whatever, whatever, than to sit and lecture and give them notes and notes about ocean currents. I think they got something out of it.

Prior to the experiment, Tammy drew on the board a complete diagram of how currents move in the ocean. Then, she divided the class into groups, had them fill a pan half full of warm water, and add a rock and a baggie of ice to opposite corners of the pan. She told them to add food coloring to the warm water and observe how the food coloring moved in the water. During the experiment, Tammy moved around the room asking questions and talking to each group. She often articulated what they should be seeing or answered the questions she posed to the groups before anyone could reply. A short discussion followed the experiment; then she gave them notes and definitions on ocean currents and surface currents to copy in their science notebooks.

That was the only lesson during her science teaching in which Tammy used an experiment to teach or reinforce a concept. Occasionally, Tammy interspersed a short activity she thought would present a concept in a more concrete manner. For example, on the day she was teaching about the heart, she had students run in place and check their pulses. While the class was studying about bones, she told them several times they were going to do an experiment on the wingspan and its relationship to height. The day of the experiment, she spent most of the period giving notes and then explained to them what they would discover when they did it. The class had about ten minutes to measure their wingspans, enough time for most of the groups to measure one person. The students never finished the experiment because Tammy felt she couldn't take the time from giving them notes on the skeletal system for the test.

After teaching the first science lesson on her own, Tammy began taking turns teaching with her cooperating teacher. Science was taught during three periods in the afternoon. The cooperating teacher taught the first period while Tammy watched her, and then Tammy taught the next two lessons. The cooperating teacher took the lead in planning most of the lessons, giving Tammy the option to plan and teach as much as she elected. Tammy began to follow the same pattern as the cooperating teacher: giving notes, quizzes on the notes, talking about the notes, asking questions, and reading out loud from the book. Tammy soon realized, "She hardly does experiments. She is not big on it. She feels it is too hard to do it with 70 kids." Tammy added, "In reality, how else are they going to do it? They need to have that information as a resource to study for the test. They have to cover the material and with all that mass . . . it seems like the only way you can get through it."

Tammy talked about how her favorite teachers had used their sense of humor to make science more interesting. She began to utilize humor and her flare for dramatics in teaching science. One day the class was compiling a chart on invertebrates, and she was trying to solicit worms as an example, so she asked, "Didn't your mom ever say to you, 'You eat so much, you must have a tapeworm?' Worms are disgusting!" Sometimes she exaggerated the words by emphasizing a vowel or a syllable, telling them the word was fun to say, like "marsupials," or had the students say the word over and over in the exaggerated form. When she was teaching the term mantle, she acted like she saw a beetle and started stomping her foot on the floor to kill it. She asked the class, "Did you hear that scrunch? One less bug to worry about." She further pretended to grind it into the floor adding, "The guts just oozed out." Finally she asked the class why stepping on a beetle makes a scrunching noise. Another day, as she was trying to obtain an example of a herbivore from the class and didn't get a response, she began saying, "Moo! Moo!" Before long she had a response.

Tammy's use of humor in her lessons became more evident as she moved into the lessons on the body systems. Humor was added to her lessons to cover up her lack of knowledge and discomfort with topics. She explained, "I honestly don't like blood and guts the way it is. So I told the class this is a new experience for me too." As she was teaching a lesson on the circulatory system, she wrote on the overhead, "Blood—Ugh—Guts." She told the class, "We are going to study about the stuff that really makes my stomach hurt. We are going to talk about blood, Ugh!" She was teaching about the digestive system and was telling the students that all the junk left over in your stomach goes to the small and large intestines. She told them that the large intestine is very, very, very long and proceeded to walk around the room as if holding on to the large intestine and stretching it out. One girl asked her how long it was. She replied, "Long," then added, "It is three to five feet, and it's all wound up inside of you. Can you feel it?" She asked the class what the large intestine did in their body. Nobody replied. So she told them that it removed the water from their body: "That is number one when you go to the bathroom." She asked them what happens if they had too much water in the intestine. Before anyone could answer, she said, "You get the Hershey's squirts. Not enough water, you get constipated, and you might have to go number two in the biffy."

Tammy believed she needed to be very knowledgeable about everything she taught because students "are like empty little things you just want to fill up with knowledge." She said,

> The more information I knew about it, the more fun I had teaching it. If I didn't know as much information about it, I was a little more hesitant to teach it. There were some areas where I wasn't as comfortable with the material and it showed. I always read the book, *always* read way ahead of what they read, because usually a question with what they are doing with you can tie into what is coming up.

Tammy relied on her cooperating teacher to provide information and answer questions about science concepts during her science teaching. She liked her cooperating teacher to remain in the room so she could use her as a resource to explain concepts to the class.

Tammy developed a pattern of asking and then answering her own questions. Sometimes she let students answer questions but repeated or changed their answers when she addressed the class. Other times she let students start to answer the question and then interrupted and gave the answer she wanted. Quite often she answered the question herself right after asking it.

As the semester progressed, it became apparent that Tammy's teaching was focused on only a few students in each class. She called on them to answer most of the questions. She called on them even when other students had their hands raised. Tammy said,

> I know who doesn't have a sensible question, like E. But then it's kids like Z. and M. who have good questions and they are smart kids and they ask decent questions, so I am not afraid to call on them.

She also relied on these few students to find answers for questions posed by the class, often sending them to check the Internet or an encyclopedia to find answers. Tammy said, "You find you can rely on them a lot. No matter how difficult or easy it is. If it is something new in science that we have never talked about, I call on them." She often talked about these students and mentioned that they were in the gifted program. "I found out that I enjoy teaching to the high learners because I enjoy moving on. I enjoy starting new things, where [with] the lower learners you are repeating always."

Tammy said many times how much she enjoyed teaching science. She told me that she did not feel that teaching science would get old:

> There is so much you can do because it is everywhere. I don't think a lot of people realize that. I didn't realize how much I already knew about science until I was forced to do it, but you would be surprised what you know and how much you can learn. My knowledge is very much increased.

However, she did not like teaching science all afternoon: "It is tiresome because—the last class gets tiresome, not only have you taught the same material three times in a row, it's the same material three times in a row." But she found that there were some advantages to teaching the same lesson several times:

> I feel that my best science teaching is the very last class because I learned from the other classes. I spent a little more time explaining the concept to them so it went the best. The third time I stopped myself and explained it thoroughly.

Wendy

Science ranked at the very top of Wendy's list of subjects to teach. She called herself a science fanatic. Her excitement and love of science and science teaching were evident from her voice cadence and rate of talking, which just naturally seemed to speed up when talking about science. Wendy, a petite young woman, was full of energy whenever I saw her during her student teaching experience. This energy was naturally transmitted into her science teaching. Some of her students referred to this high energy in their science journals: "Mrs. W is nuts. She is literally crazy."

Wendy found countless ideas for teaching science concepts but had difficulty trying to decide which ones to use. She simply wanted to try them all. Wendy spent countless hours preparing. She reported,

> My major work and my time is spent on science. Researching it, figuring out what is the best way. I have this concept, "What is the best experiment, hands on experiment, that I can do that will make the connection?" I probably had 30 books on just weathering and eroding at my house. I was just picking four [experiments] from them. I have so many books at home and I have started and I will change it and I will get an idea and I don't . . . and I will call my mom and say, "Think they will get it if I say this or if I do this activity?" More than hours, days! I mean a good week, constantly at the library.

Wendy's curiosity about everything on a topic was an offshoot from her childhood. She said, "I was always curious, always questioning. How does this work? Why does this work? I would always manipulate things . . . curiosity never stopped with me . . . actually I was probably a very annoying child because I was always questioning." As a child, she remembered digging in the dirt looking for earthworms, experimenting with bugs to find out what kind of food they would eat, and playing nurse on her dog. She felt that science just seeped out of her and knew she loved science at an early age. She explained, "I never knew it was called science. I was just curious . . . it was just an instinct for me." It was during the sixth grade that Wendy made the connection between her natural curiosity and science. Her sixth-grade teacher introduced microscopes and encouraged scientific investigations throughout the school year. She became interested in biology that year, which led her to pursue a minor in biology in college.

Curiosity is still an integral part of Wendy's life. She related several examples of this during our interviews. She told about the time she picked up an elementary science textbook and started reading about astronomy. She found herself at the library that evening looking for more information on astronomy. When she decided to plant a small garden last summer she related how she read everything about gardening during that time.

Wendy believed that students at the elementary level do not feel the same way about science that she does. She said, "I already know that all kids basically hate science and trying to make it fun for them . . . for whatever reason, they just hate science. They need the understanding that science is more than just answering questions." She added, "Kids are so afraid of science. I feel it's so important that it is hands on. It is so much more fun to do. They will get excited. They say they hate science but when you do it, they have fun." The students in Wendy's classroom did not seem to be interested in science when she began teaching it. Many of them did not like to try experiments. She found it was hard to get a discussion going. She reported they would say, "Just give me a worksheet." This challenged Wendy to find ways to get them more involved and enthusiastic about science. Once she got her students involved in hands on science experiences, Wendy felt they had a "blast" and wanted to try more experiments.

Wendy was assigned to a fourth/fifth combination room for her student teaching. Within three weeks, the cooperating teacher had turned over to her the responsibility for teaching all the subjects to the fifth-grade class. There were only nine students, but the dynamics of the group made teaching a challenge. The class did not work well as a group. There were two girls who displayed strong leadership traits, but did not work well together, and were constantly trying to control the actions of the other students and Wendy.

The dynamics of the class, along with Wendy's desire to spark interest in science, led her to try various approaches during her student teaching. She liked to start science lessons by having the students read a short section out of the book and then asking them questions about it. She used this approach both to determine her students' knowledge on the topic and to motivate their curiosity. The class reacted variously. Sometimes they answered her lead-in questions and added other questions related to the topic; other times some of the class started talking to each other, ignoring Wendy's questions, causing

Wendy to focus on the few children who were interested; other times they asked questions that were totally unrelated to the topic. On many days, Wendy found it hard to draw the students' attention on the lesson, so she fell into the pattern of telling them the information she wanted them to know, repeating it several times, and then checked to find out if they understood her by asking them to relate facts back to her. She tried activities in small groups, explaining the activity to the entire group and then sending students to different parts of the room. Usually the students did not know what they were to do when they got to their area, causing Wendy to go around and explain it all over again. Frequently the group work evolved into arguments about how the activity was to be done and who was going to do it. Often, Wendy was kept so busy with the groups that she did not have time to bring them together for a discussion of the results of the activity.

The following example illustrates a group activity in Wendy's class. The class was studying how landforms might have been made. Wendy had prepared a large world map, cut into sections. Each group was to locate and mark five types of landforms on a section of the world map. Then they were to mark different sized mountains on the map with paper mâché. Wendy had divided the class into groups by gender. The boys were able to accomplish the task quickly, but the girls argued over who would draw on what part of the map and then played around with the starch and paper, each one trying to make the highest mountain. The map was so messy that Wendy simply threw it in the garbage, made a new one, divided the class differently the next day, and allowed only crayons to mark the landforms. Still they argued over what colors and symbols to use in marking the landforms, causing Wendy to tell them what symbols they could use.

Another approach Wendy used was to conduct experiments in front of the class. She would ask one or two students to assist her, and asked them to predict what would happen when she directed them to do something. She usually spent time trying to find out what the students learned from the experiment before she told them what she thought they should have learned from it. She also tried stations, which worked well for her, if she had explicit instructions at each station. The students were directed to do an activity according to the directions they had been given. She would say, "Read this and it will tell you your procedure. That is what a scientist does. They have to follow procedures, and if you are scientist, this is what you have to do." At each station, students were to predict what they thought would happen when they did the directed activity. When she first asked them to make predictions, their response often was "Will I get it marked wrong if it is not right?," but later they were willing to make predictions. Wendy shared that she wanted them to "do it right" at the stations so her lesson would turn out the way she expected. This led her to go around to the stations and make sure everything was done correctly. During one lesson I observed, the students at a station were given instructions on how to make a mountain out of sand and then directed to place a chunk of ice on it, as a glacier, and observe what happened as the ice melted. The group put the chunk of ice on the very top. Wendy came over to the group, removed the ice, reshaped the sand into a mountain, placed the chunk of ice on the side of the mountain, and told them that glaciers move down the side of a mountain.

Some of Wendy's decisions about her science teaching were based on her perception of the class. She decided that experiments that might involve several trials would have to be done in a whole group demonstration setting. She observed, "If I give them any challenge, they shut down. They get frustrated with me and they start pouting." As she came to understand her students' reactions, she began to adapt her teaching to their needs, reflecting, "If it gets too difficult or if it doesn't come right together real quick, they will shut down. Then if I try and explain it, they don't even want to listen to me." Eventually, Wendy began to develop a packet of instructions for each activity that included exact instructions on how to do the procedure and questions that related to the activity. Wendy developed the activity work packets based on the experiments that she had chosen for them to do. She lamented, "In the end was more asking questions on pencil and paper, and then I would discuss it in small groups rather than do it in large groups cause it was almost impossible with this class."

Wendy's philosophy of science teaching was that science concepts needed to be made meaningful to students if they were to understand them. She worked very hard at finding ways to make the concepts of weathering and erosion concrete for the students. She used a steady stream of water running from a faucet onto a bar of soap to teach water erosion. The students predicted how the bar of soap would change over the day and then wrote observations of how and where the soap's shape changed. Still, Wendy was not satisfied that the soap experiment had made a connection between water erosion and canyon formation, so she told her students that she could have used a rock, but they had to graduate in eight years and they wouldn't have seen any change in eight years, anyway. "They just snickered at that. They got the point."

Making the connection was her criterion for the success of a lesson. She said, "I just cross my fingers thinking, 'I hope these kids don't sit there and think this is dumb.' You put so much effort into it, and if it doesn't make the connection, it doesn't work. Every lesson, that is my fear." Another time, she stated, "If I don't think something is going to get across to the kids, that they are not going to learn anything from it, then why do it?" She tried a wind erosion experiment with a newly painted board to which she had applied sand while the paint was still wet. The sand and paint were to come off when she applied a hair dryer to the board. It didn't. Wendy was still satisfied: "They got the point. It didn't work well because the hair dryer wasn't strong enough."

Another time, Wendy decided to use asphalt to conduct an experiment on weathering. She wanted to connect the weathering process to potholes in roads. She related to me how she drove down a highway outside of town several times until she saw a construction area where some asphalt had just been broken up. She stopped and picked up some chunks of asphalt that had cracks in them. She said, "I wondered what I would say to someone if they stopped and asked me what I was doing out in the dark collecting chunks of asphalt." The following morning, the class went outdoors in the cold air and poured water over the pieces of asphalt. After the water was frozen, the asphalt was brought inside until the ice melted. After the ice had melted, the asphalt was taken outside and water poured over it again. This procedure was repeated throughout the day. By the end of the day, several of the cracks had gotten larger, and one chunk of asphalt had split into two pieces along the crack line. Wendy said she kept thinking, "What if this was all for nothing and it doesn't make the connection?" She was excited that this experiment had worked so well.

Wendy once expressed that science inquiry was letting students investigate things themselves without giving them guidelines. She felt students should test out theories based on their conclusions from other investigations. Yet she worried "about letting kids come up with how things work on their own . . . they figure . . . they come up with an hypothesis." More specifically, she did not trust herself to try inquiry with the group she was teaching: "These kids come up with this and they are like Ooo. . . . So I just got a little worried about things they come up with on their own. Their imagination goes wild."

Wendy intends to teach science actively in her own classroom. She hopes to collaborate with other teachers, especially at the same grade level. She would like to encourage other teachers to become more involved in teaching science through sharing of ideas. She is realistic that this may not happen, as many teachers want to "teach with the door closed." She also fears that she could begin to feel a little resentful toward other teachers, especially if she is putting in all the hours trying to teach science and others are just teaching by reading the science book and never doing science experiments.

Mary

Mary had looked forward all summer to student teaching in the fall. She expressed her eagerness, excitement, and nervousness about her fourth-grade student teaching assignment during our first interview session. Mary described herself as a pleasant person to be around, a very fitting description for this 21 year old preservice teacher. She had a smile which came easily and readily when she was conversing. When Mary arrived at our second interview, her demeanor suggested that something was not quite the same with her as in the previous meeting. Gone was the enthusiasm I had previously heard about student teaching. We were about 20 minutes into the interview when she revealed serious doubts about her ability to teach. With a shaky voice and tears in her eyes, she said, "I go home wondering what I am doing. Why am I here? I hope this is a common thing, when you are going through this stage of school, where I think a lot of people do just question." Several factors entered into her dilemma about whether she was in the right profession. She was in her fourth week of student teaching, but had only been given limited opportunities to teach by her cooperating teacher. She commented, "Actually she hasn't given me much but backup stuff. A lot of it is just observing and helping individual students if they need help. Every day I do teach something even if it's only the opening." She admitted that she struggled with her attitude and indecision about teaching more on the days when she just sat and wasn't doing anything. When she did teach, Mary found that she was nervous and that took away from her enjoyment. She felt pressure from the fact that someone else was present and she didn't want to "be a failure." She hadn't received much feedback from her cooperating teacher and was not sure how to interpret the feedback she had received on a letter writing lesson she had planned and taught. Mary reflected,

> It was better than I thought it would be and I don't know if it is because I put a lot of pressure on myself. I kinda feel like she is thinking that this is her first lesson and I want her to feel good about it. I hope that wasn't it. I hope it was because I

> did a good job. But I can see the other way around and see what a teacher is thinking: "Do I want to support her and do I want to give her some esteem that she is doing a good job?"

Mary also felt conflict between what she had learned in her teacher preparation classes and the reality of teaching in the public school: "It is a lot different from school. What you learned in school. I go in there and worksheets are all the time. . . . I feel it was drilled into my head—no basals."

Mary came into our next session in a more upbeat mood. Her smile appeared often and she was more talkative. We had communicated twice in the interim about the mini lessons she had taught in science, and both times she reported things were going better and she was finally getting to teach more. During this interview, Mary was eager to talk about her experiences in teaching science although she was still apprehensive. Mary's first experience in teaching science was with earthworms. She was handed a lesson that the cooperating teacher had planned to teach but decided at the last minute that Mary should teach it instead. Mary had the students explore with the earthworms following the instructions on the activity sheets. Several days passed before she was able to discuss the findings with the class because the cooperating teacher wanted to finish up other lessons from the book. Mary felt it was important to find out what the students had discovered from experimenting with the earthworms even though follow-up discussions were not common in the classroom. She enjoyed dialogue generated with the students, saying, "I *like that* when the students go off and do and talk about stuff. They loved working with the earthworms."

Mary wanted to make science come alive to students. She realized that not every lesson could be taught hands on:

> There is a little more work involved with an experiment. That might work best, but it's not always going to happen. I have to find ways to bring it to life. There are certain questions I can ask and just have a lot of conversation.

Mary knew that less direct methods such as videos or laser disk clips of animals or plants could be used to enhance student understanding of information presented in the textbook. She felt that good questioning was important and could lead to students learning from each other.

During Mary's first experience of planning and teaching a science chapter on her own, she tried different methods to make the concepts relevant to the students' world. She used pictures and laser disk clips of animals, live animals, experiments, textbook reading, discussion, short activities, and the vocabulary sheets required by the cooperating teacher. She tried to apply the vocabulary they were learning in science to everyday objects. She once held up her cup and asked, "Is this unique? How could it be unique?" Questions were commonly used in her lessons. She explained, "That is just a strategy that I use to involve them all. Then if they don't have their hands raised, I just say to them, 'What do you think?'" She asked questions to review concepts from previous lessons, such as "Can you explain what a vertebrate is? How do you know you are a vertebrate?" She generated questions based on students' responses and their interests as revealed in class discussion. Mary accepted any response students might give, and if the students were unsure of their answer she asked further questions to clarify. She related, "Even if I can't bring something in, the discussion I think is so meaningful, and we try and go off from the text. . . ." Mary felt that her students' ideas were important, so often her beginning discussions took up more time than she planned, and she had to rush through the experiment.

Mary tried several experiments during her science teaching. She tried activities from the textbook, adapting them as needed, and from the resources her cooperating teacher had on hand. She brought in goldfish to enable discovery of how changes in temperature can affect the breathing rate of vertebrates. She gave each group a goldfish, but before they could do any exploration, they had to identify the physical characteristics of their fish, write a description of their fish, and name it. Then they recorded the water temperature, counted the number of breaths the goldfish took in one minute in the regular water, added cold water to the container, and repeated the procedure. The class ran out of time, so the next day Mary graphed the class results on the overhead. She led discussion of what conclusions could be reached from the graph. Before long, several students decided that more testing was needed since some of the groups may not have recorded the information correctly or because the sizes of the fish were different, but disaster struck the goldfish before the tests could be repeated. Two of them died, leading Mary to open her science lesson the next day with a short discussion of why the fish might have died.

Mary brought in live lobsters to connect the information on exoskeletons in the textbook to the real thing. First, the class read and discussed the information about mollusks in the textbook. She showed a video from Red Lobster, posing in advance three questions for them to find answers to while viewing. Following discussion of the questions, she asked the class to describe a lobster. One student replied, "It would be easier to describe it if I saw one." She opened the classroom door, and two employees from the Red Lobster brought live lobsters into the room. She felt it was important to develop background information before the students did any type of activity, stating, "If they don't know what to look for, then it is going to lose the whole reason for it." The students were divided into two groups which had the opportunity to touch the lobsters, hold them, and learn firsthand information about them. Since the lesson went right up to lunch time, Mary followed through with a short discussion after lunch to share what they had learned.

Science was scheduled in Mary's fourth-grade classroom for a 40-minute period right before lunch. Mary frequently ran out of time when she was doing a science experiment. Time became a real issue in her science teaching:

> I think doing science right before lunch, it is one of those things that if you are doing things and sure you can come back after lunch, but you lose part of it, I think. In a normal subject, you can stop and come back to it easier.

If she could not bring a lesson to conclusion after lunch, she began her next lesson talking about the previous activity and what they learned from it. She realized that this did not always provide the best learning situation.

Mary found herself doing more science experiments and activities as she moved into the unit on matter. She was told she needed to cover the material in the book, but she felt the concepts of mass, weight, and volume were too abstract for the students to understand by just reading and writing out definitions. She struggled with understanding the concepts herself as she sought activities that would make them more concrete to her and her students.

Mary used groups when she did activities. She wanted the students to discuss things when doing experiments. She encouraged the groups to share ideas and often posed questions designed to get them to talk with each other. Mary reported that this often resulted in more noise than the cooperating teacher liked to have in the classroom. One day I observed Mary teaching a lesson on classification. She started in a large group and had the students decide on a category for splitting themselves into two groups. Once in two groups, each had to decide how to split into two new categories. The room became noisy as the students talked among themselves about categories for division, and there was some goofing off among the boys. After the third division of groups, the cooperating teacher stopped the lesson, told the students they were too noisy and disrespectful, and then conducted the activity using a slightly different format. Mary was visually upset, almost to the point of tears, after the students left the room to go to lunch. All she said was, "I am so frustrated. She is still jumping in. She will see something or if a certain child is acting up, she will correct him. I should be doing that." Mary said that the cooperating teacher stayed in the room almost all of the time when she taught, especially during science, noting that her cooperating teacher had told her that this was her normal pattern: she preferred to stay in the room with her student teachers. Mary realized that a difference in noise tolerance existed between the cooperating teacher and herself: "We have different philosophies on how the room, you know, how what should go on in the classroom." Mary wanted to have the opportunity to develop her style of interacting with groups within the science setting. She was able to teach two lessons without the cooperating teacher in the room toward the end of her student teaching and reported that she thought it went pretty well:

> I don't have to worry so much about the noise or what is going to happen. It is not such a big deal if they get excited, not that I didn't want them to get excited before, but I was just worried that it was going to . . .

Mary ranked science second, behind math, as her favorite subject during student teaching. She said, "I had a lot of fun with it this semester. I thought the kids really enjoyed it and it was a lot of fun." Mary is looking forward to teaching science in her own classroom:

> There won't be another teacher watching me. I will feel a little more . . . at ease, a little more able to do what I want to do. I think the true me will come out. There is always that little reserve where you just don't want someone to watch. . . . There were times I thought . . . we could have spent another day on this or if I could have did . . . I can do things my way now.

She realized that her ideals for teaching could conflict with reality and gained from her student teaching a greater realism about the profession of teaching.

CHAPTER V

FINDINGS

The purpose of this study was to find out how six preservice teachers made meaning of science teaching during their student teaching experience. The analysis of the data derived from observations of science teaching by each participant, documents (particularly lesson plans), and participant interviews revealed 27 codes that were collapsed into five categories. Some of the data in the codes fit into more than one category, indicating that overlapping themes and patterns were present in the data. The five categories that were developed from the codes were influence, feelings, reality, strategy, and science.

The categories were then examined closely to find themes or patterns that were present in the study. I asked myself, "How do the categories affect or how are they affected by each other?" Two themes or patterns, which intertwined throughout the data, emerged. They were (1) personal and professional career influences and (2) constant adjustment of teaching strategies. From these themes, assertions or conclusions were advanced. These statements about the themes are presented in this chapter with evidence to support each one. Evidence was obtained from interviews with the six student teachers in the study, observations in their classroom settings, and artifacts of their teaching. Code names have been used to protect the anonymity of the participants, the setting, and others mentioned in the text.

Assertion #1: Student teachers' views of science teaching are influenced by personal memories as well as by nonprofessional and professional mentors.

Personal beliefs about teaching and specific images about science teaching held by some student teachers influence their experiences with science teaching. Student teachers talk about their beginning teaching experiences with many people including friends, acquaintances, teachers, family members, and others with whom they can share their anecdotes and general thoughts about teaching. Some student teachers build mentor relationships with their cooperating teachers or seek mentors among the significant people in their lives, people who can give them advice and feedback about their teaching. Cooperating teachers can influence a student teacher's science experience by their teaching approaches and their scheduling of science.

Sub-assertion 1A: Personal images of science teaching influence the act of teaching science.

Preservice teachers enter their student teaching holding beliefs about teaching formed from their prior experiences. Some hold only general images of teaching, while others are able to articulate visions of how they wish to teach certain subject areas in the elementary curriculum. During the first interview, three of the student teachers in the study described how they saw themselves teaching science. The others were not sure how they planned to teach science. Wendy believed that all students should enjoy science and be involved in hands on learning. She wanted children to go home excited about science so that "it will become a lifelong adventure for them." She wanted to make science relevant and meaningful to her students' lives so that they "could see it in their own world." Wendy wanted to use both hands on activities and discussion when she taught science. She explained,

> I try wracking my brain for ideas. How can I get their hands into it? I want them to be active. I want to get them right into an activity . . . the only way I can think of to get them enthused, involved in science, is more activities.

Rochelle believed that students should learn to think like scientists when doing science. She believed that the students should test things several times and learn to collect a wide variety of data to analyze before drawing conclusions from experiments. Mary felt that science had to have a connection to students' everyday worlds. She said, "I would like to make it [science] as real as possible, you know, make that connection." Although Mary felt that experiments made science more meaningful to the students, she wanted to find ways to make the textbook reading meaningful to them, as well.

Their attempts to implement their visions of themselves teaching science led Wendy, Rochelle, and Mary to look for strategies that would make such teaching a reality. Wendy had students whom she believed went through the "motions" in science and did not want to take part in discussion but only wanted to "do a worksheet." Wendy tried a variety of approaches with her science activities to get the students involved. She changed and adapted her strategies for activities as she wrestled with student attitude and classroom management. She began teaching science by doing hands on activities in groups. When she encountered problems with group management, she tried using more class discussion before she had them work in groups. This did not work well either, as the students started talking to each other or they were reluctant to respond. She kept questioning herself, saying, "The problem is I don't know if I am doing it the right way."

Wendy changed to doing demonstrations in front of the class and whole group activities. She often commented, "You put so much effort into it, and if it doesn't make the connection, it doesn't work. That's my fear." She finally discovered she could get the students to discuss the concepts when she placed them at stations doing very directed activities. She made up worksheets and packets for the activities that had all the steps written out and questions to answer after every procedure. Then she went around to each group and discussed with them what they were finding or doing. She commented,

> I was not ready for them to shut down on me. . . . I am experimenting with my own teaching style. . . . I really have to be limited in what I try because I will just struggle . . . it is like, give them the step by step. Isn't that dumb?

As the semester ended, Wendy was not sure the students in her classroom ever adjusted to hands on learning in science. She wondered if her high energy level had detracted from their learning and thought she might need to add more structure and flexibility into her science teaching to help students "like hands on science."

Because she was eager to implement her image of science teaching, Rochelle tried to squeeze as many activities as she could into the three weeks she taught science. Rochelle commented, "I wanted to try this and try that." She realized that not all of her activities provided the opportunity for the students to think like scientists. She felt her saturation experiment failed in this regard because it was too pointed. She said, "I just grabbed onto it cause I knew they were going to have a test on saturation." Rochelle tried a penguin activity where the students had to walk around with an egg on the top of their feet all day pretending they were penguins incubating eggs. She realized that doing it as an isolated activity did not provide the background to help the students really investigate.

She commented, "[They should] have learned about penguins the whole week and then I could have used the activity as a culminating thing. It would have helped." Rochelle believes she will not always be able to use hands on activities in her science teaching but she wants students to "see the purpose for doing hands on science and learn to think like a scientist" in any approach she chooses to use.

Mary believed that science had to be relevant to her students' lives if they were going to understand it. When Mary began teaching science, she was unsure of her teacher presence in the classroom and was looking for a strategy to implement her vision with a large group. Her first approach to teaching science was reading and discussing the material in the book, and using questions to help the students apply the knowledge to their everyday lives. Mary felt that talking and questioning were important before students did activities: "They kinda know what to look for. If they don't know what to look for, then it is going to lose . . . the whole reason for it [activity or experiment]." Mary included many experiments and activities in her teaching as she searched for ways to make science meaningful to her students.

Tammy was searching for a personal image of how she wanted to teach science. She wanted science to be "fun" but was unsure of how she wanted to do it. She hoped that her cooperating teacher would do "neat, fun things" in science so she could learn from her. Tammy's first thought when she was given a lesson to teach was to try an experiment. She wanted to give the students a break from the "boring stuff" like reading and taking notes, saying, "It's more fun to do hands on." She did an experiment of ocean currents. After trying that one experiment, Tammy began to adopt her cooperating teacher's approach to teaching science because she believed, as did her cooperating teacher, that "children are empty little things you just want to fill with knowledge." Tammy moved into a pattern of lecturing and giving notes, adding humor, drawings, and simple actions to her approach to keep the students involved. She also used class discussion in her teaching but only encouraged a few students in each class to participate actively. She explained, "I enjoy teaching to the high learners so we can keep moving on." At the end of student teaching, Tammy realized that it was important to make science relevant to students. She said, "Relating it to . . . a real life experience that we all have in common . . . I think it makes it a lot easier to understand." Tammy felt that she would probably use the textbook approach for science teaching in her own classroom but thought she might try to do more experiments in the future.

Like Tammy, Sam and Angela bought into their cooperating teachers' mode of teaching completely in the absence of a personal image of teaching science. Sam thought experiments might be fun but was not sure if he would use them. When Sam started teaching science, he found his first approach worked for him, so he continued to use that basic strategy. Sam adopted his cooperating teacher's general mode of teaching and applied it to his science teaching. He followed his cooperating teacher's advice and taught science in a large group because "there is so much material for them to comprehend." Sam taught science as reading, recall of facts, and telling. At the end of student teaching, Sam still did not know how he would teach science in his own classroom, stating, "It will depend on the group."

Angela never mentioned how she thought science should be taught in an elementary classroom but offered her vision for teaching social studies and math. She had a different vision for each of the subject areas. She believed that students should work together as a community of learners in social studies but, in math, she believed that each child should find his/her own way to learn. Angela explained during the first interview that she felt learning needed to be made relevant to students' lives, a belief she found easier to implement in subjects other than science. Angela patterned her basic approach to teaching science after her cooperating teacher's. She related, "I based a lot of it [teaching] on when I watched my teacher teach science." At first Angela tried to add more discussion to the reading, demonstrations, and diagram drawing and promote critical thinking through open-ended questions, but, as she taught more, she became more focused on the students' remembering the facts and terms that had been covered. She spent a part of each class period reviewing the terms, "talking about them every day," and even started giving small quizzes on them. Angela was using fewer experiments and more writing in science by the end of the unit. At the end of the semester, Angela was still uncertain how she would teach science in her own classroom but hoped to make it more hands on.

Sub-assertion 1B: Personal mentors can support science teaching.

Significant people in a student teacher's life who are interested in science can influence them to become active teachers of science. The student teachers in this study sought other student teachers in their buildings, family members, friends, other teachers, their cooperating teachers, and significant people in their lives as mentors or sounding boards. Knowing that someone understood their concerns about teaching or could revel in their triumphs was more important to some student teachers than to others. Tammy talked to her father, a community college math teacher, reporting, "He just asked 'How is it going? What are you doing?'" For day to day help, she preferred to seek out her cooperating teacher and other teachers because they had more direct knowledge of her immediate level of teaching. Angela used her boyfriend as a sounding board for ideas she thought she might use in teaching. He offered his advice but only when it concerned an area of elementary school that he had not enjoyed. Angela maintained a professional relationship with her cooperating teacher and sought her advice on scheduling, teaching techniques for particular lessons, and operation of some science equipment. Mary was hesitant to talk to anyone about her teaching at the beginning of her experience but later began to share with other student teachers in her building. She maintained a formal relationship with her cooperating teacher, limiting discussion to pertinent matters at hand, such as scheduling, assignments, and materials. Sam reported having no family who could relate to his experiences because he was the first to pursue a teaching degree. He shared stories with his family and friends but did not want "to bore them with too much." Sam's cooperating teacher became his mentor during student teaching. Sam liked to talk to his cooperating teacher about his teaching because he felt that no one else would understand his concerns and know what he was experiencing. He sought his cooperating teacher's advice before he taught lessons, after lessons he taught, and for general school decisions.

Rochelle's mentor was her husband. Rochelle professed that she had become more interested in teaching science since her marriage to a scientist who wanted to become an astronaut. Rochelle admitted that she had gone through stages of being interested in many things, but she is now "gearing" toward math and science because "My husband has shown me how much fun they are. He likes to do hands on science and does experiments with me." Rochelle used a hands on approach in most of the science lessons she taught, talking over her ideas for most lessons with her husband, reporting,

> I talk about these things constantly when I am home with my husband. My husband is great to talk to because he is so good at just listening to me and saying, "Rochelle, that is a great idea, but maybe this will work too." He will explain things to me, as well. He is very encouraging to me.

Her husband provided additional support to her science teaching by helping her gather supplies for her experiments.

Wendy sought the advice of her mother-in-law, a science teacher in another state, to help direct her energy into concrete learning experiences for her students. Wendy told me many times "I love science." She had a strong natural curiosity, which she wanted to instill in her students but her enthusiasm often led her off in many directions. Wendy said she often called her "mom" and asked, "Do you think they will get it? Will they get the point?" Sometimes her mentor would tell her that she was "far reaching or right on the mark." Wendy reported, "I will ask my Mom. Here is an experiment they have [in the book]. Here is an idea I have. She would kind of manipulate my idea. 'You might want to think of this'. . . I did use some of her ideas and some of mine." Wendy tried many hands on activities during her science teaching. She often said in our interviews that she might have given up trying to get the kids involved in science if she had not had her mother-in-law to draw on as a resource: "She explained it's just a learning process. She gave me advice and more ways to look at it."

Sub-assertion 1C: Cooperating teachers have positive and negative influences on science teaching.

The general attitude and approach to science teaching perpetuated by a cooperating teacher can influence a student teacher's decision about how to teach science in the classroom. Each cooperating teacher's approach toward science was different. Some of them never taught science, while others used a traditional textbook approach. Two of the cooperating teachers used some hands on activities in their teaching. Although some of the cooperating teachers were willing to let their student teachers try a hands on approach, others did not support this type of teaching.

The impact of the cooperating teachers' science approaches on the student teachers varied. Wendy's assignment to a combination room with a cooperating teacher who had never taught in this arrangement reduced the influence of a cooperating teacher on her science teaching. The cooperating teacher turned over the planning and teaching of the fifth grade to Wendy within the first month. They worked in the same room but did not share ideas on teaching. Wendy said, "She wants me to be independent. We don't really discuss anything." Early in her student teaching, Wendy had watched her cooperating teacher teach science and decided not to follow her teaching strategy. Wendy explained, "She put the lesson on fingerprinting into too small of a time and tried to cram it in and she should have stopped. . . . It was way too quick, and she didn't give them time to investigate. They weren't learning anything." Wendy wanted science to be relevant and meaningful to her students so she used different approaches than her cooperating teacher to accomplish her goal.

Rochelle's cooperating teacher did not influence her science teaching directly. Instead, her influence came through her willingness to let Rochelle explore various ways to teach science. Rochelle's teacher said many times that she did not like teaching science. She suggested that Rochelle go next door to observe Mrs. P. teaching science but did not follow up by making time available for Rochelle to go. Rochelle said, "She just lets me go. She doesn't tell me what to do. I said, 'O.K. Cool. I want to try this and this and see how they work.'"

Mary's cooperating teacher was actively trying to add more hands on activities to her science teaching, and Mary observed her model several hands on activities. Mary adapted some of the strategies her cooperating teacher used but did not agree with others and did not use them in her teaching. Mary referred to her cooperating teacher as "so organized." The cooperating teacher used a lot of worksheets in her science teaching, and Mary commented, "She says it's her way of supplementing. To me it's the same as the book." When they did an experiment on earthworms, Mary reported, "She had a sheet that they followed. . . . There was a sheet to follow for the three experiments they had to perform." Mary found that "there wasn't much follow up" to the hands on activities. Her cooperating teacher used the textbook and added AIMS activities that corresponded to the topic. Mary reported, "She uses pictures and diagrams too. The book is for experiments, definition sheets [of terms] they have to do and other worksheets."

Tammy's and Angela's cooperating teachers' approaches to science were a direct influence on their science teaching. They copied their cooperating teachers' approaches because they felt they worked best for their classroom settings. Tammy anticipated, at the beginning of her student teaching, that she would be doing a lot of hands on activities, since she was assigned to a classroom where the teacher taught science all afternoon. She soon found that her cooperating teacher held a different philosophy of science teaching. Tammy stated that her cooperating teacher used a lot of notes saying, "A lot of her science is take notes, quiz on notes, talk about notes, questions, we read out loud from the book." A pattern evolved in which Tammy did not plan the lessons taught. As she said, "If she plans the lessons, she teaches the first period, we take turns on the second one, and I teach the third." On her turn to teach, Tammy followed the same approach as her cooperating teacher although she was given the opportunity to use any method she wanted when she had full responsibility for the classroom. Tammy commented, "She wants to cover this material and with that mass, it seems the only way you can get through it is the way she does it." Tammy thought about adding demonstration experiments to her teaching but did not, saying, "She [cooperating teacher] wasn't big on them [experiments] so I didn't push it. I didn't want to overstep my ground."

Angela followed her cooperating teacher's approach when she started teaching science. She watched her cooperating teacher teach two chapters on microorganisms before taking over the unit. Angela was not sure if she liked her cooperating teacher's approach, saying,

> They read out of the book. They drew some cells. The teacher guides them through [the activities] and they sit at their desks and watch. Every once in a while she . . . like yesterday, we started one that has a bullion cube in water and you add vinegar in one and salt in the other and you see if they grow organisms. She will have people come up and help and pour stuff in and do whatever but she

> does the work. We looked at buttermilk cells under the microscope and they drew those.

Yet, she adopted the same pattern of using the book and the materials from the curriculum kit because her cooperating teacher told her that "it was the only way it would work with the schedule and the layout of the book." On the advice of her cooperating teacher, she used only experiments from the book because the materials were easy to obtain.

Sam never saw his cooperating teacher teach a science lesson, but he was influenced by the type of resources she helped him locate. She suggested that he do a unit on bones for science "since October was a good time to do it." She helped him locate worksheets for the unit, referred him to another teacher for resource material, and helped him with art projects connected to bone lessons. Sam both liked and disliked the freedom he was given, saying,

> I like the freedom cause you don't have to follow along, but when you run out of things to do or you can't think of something, you can't fall back on something. I can't think of anything for tomorrow. I went and got some videos on bones. I have to take them home and check them out and see if they are suitable for the kids.

When Sam started teaching about the rocks, his cooperating teacher brought out her rock collection, but they never discussed how Sam might use it in his teaching. Consequently, he never did.

Cooperating teachers can influence student teachers by supporting their efforts to try various approaches to teaching science. Mary's cooperating teacher influenced her science teaching through actions and resources more than through interactions with her. Her cooperating teacher encouraged Mary to use activities from the resource books available in the room. She taught Mary how to use the laser disk machine to access visual material for her science lessons, helped her find videos pertaining to the animal unit she was teaching, and brought in some supplies for the experiments she knew Mary planned to teach.

The teaching of science was not discussed in depth between the cooperating teachers and the student teachers. Discussion on science teaching was usually limited to scheduling and the material to be covered in a unit. Wendy said, “She wants me to be independent. We don’t really discuss anything.” Tammy told me several times that she and her cooperating teacher seldom talked about science teaching except for planning who was responsible for what lesson or discussing what information had to be covered in the unit. Angela stated that she and her cooperating teacher never discussed anything in depth. For teaching science, Angela was simply given a list of activities that her teacher had previously used with the unit she was teaching. Angela stated, “She told me not to even try that one [experiment] or that one probably won’t work. She never said, ‘You should try this or this.’”

A cooperating teacher’s overall teaching approach can also influence a student teacher’s approach to science teaching. Mary’s cooperating teacher did not like the students to talk to each other during science activities. This caused Mary some concern when she did experiments because she wanted the students to interact with one another both in a large group and in cooperative activities. Sometimes the interaction increased the noise level in the room. When this happened, Mary's cooperating teacher would intervene, which upset Mary.

<u>Sub-assertion 1D: Scheduling is one way cooperating teachers influence the teaching of science.</u>

Cooperating teachers influence student teachers' experiences in teaching science through scheduling. Cooperating teachers decide when and for how long science is a part of a student teacher's teaching load. Science was one of the last classes added to the teaching loads of most of the student teachers. With the exception of Tammy and Wendy, the student teachers did not teach science until approximately six weeks into their assignments. Most of the participants taught science during the middle eight weeks of their 16-week assignments, usually in October and November, a period of the school year that includes several breaks for parent conferences, teachers' convention, Veteran's Day, and Thanksgiving. These breaks limited the days available for science teaching.

The hour when science is scheduled in a school day, the length of the class period, and the number of days in a week it is taught are all scheduling factors which influence the science teaching of elementary student teachers. Although some of the scheduling is beyond a teacher's control, science seemed to be cut before any other subject in some teachers' rooms. Several configurations were used in the scheduling of science in the student teachers' classrooms. Science was taught all afternoon to three classes in Tammy's room, while Wendy's and Rochelle's classes had no scheduled time for science. Science was scheduled for the last period of the day in Angela's and Sam's classroom and for the period right before lunch in Mary's classroom. When science is scheduled at the end of the day, it is often cut for various reasons, limiting the time student teachers have available for teaching science. Sam related, "I did [science] probably four days out of the last three weeks. That was it. Programs, practices for stuff, artist in the classroom. . . . There were tons of things they had to do." Several times I came to observe Sam or Angela only to be informed that science was not going to be taught that day. One day in November, I stopped by Angela's classroom, and her cooperating teacher told me that they weren't having science for awhile because time was needed for art projects and music program practices.

Science teaching time was often reduced because the class before it went over time. Angela reported,

> When it is at the end of the day, you almost lose the last 15 minutes of the day anyway, because the kids are so excited to go or they have to have notes passed out to them, and the announcements come on. I think every week they got back from gym later and later. It started out they were supposed to be done at 2:20. Well, a lot of days they were going out to the field, so they couldn't get back in until 2:30. They had like 30 minutes [of science] which probably turned into 20 considering they had to get ready to go home.

Mary encountered many of the same situations as Angela because science was scheduled for the period right before lunch. She found it hard to finish activities or even do experiments on certain days because the class period was too short. Mary stated, "Different things cut into it—library, computer. I don't know if it's the scheduling, but there are times the kids get taken away too. I think doing science right before lunch . . . sure you can come back after lunch, but you lose part of it." Mary found that she often ran out of time to complete her lesson, especially when doing hands on activities. She reported,

> I let it go too long because they all had fish stories and talking about fish and we didn't get going until 20 after. It really got close to 20 to and there was a crunch of time and didn't get as much done.

The time scheduled for science worked to her advantage when she was trying to prepare for experiments. She used music, gym, and recess time to set up her materials and collect her thoughts on the lesson.

Sometimes, science is scheduled for two or three days a week or rotated with other subjects in the elementary curriculum. Angela did not like the three-day schedule for science in her classroom. Angela reported,

> We had it scheduled as Monday and Wednesday for an hour and Tuesday for 50 minutes. But everything else we had every day for about 45 minutes. It was so inconsistent. Three days and then have two days off. A lot of times we didn't get the full three days of them in.

Angela felt time scheduled for science dictated how she could teach science. She did not want to leave an idea undeveloped from Thursday to Monday, as she knew the students would forget. She explained,

> It's not like you could read about all the stuff on one day, do an activity, and then the next day do an experiment. So its kinda read a paragraph, talk about it and that sometimes only takes ten minutes, but then you still don't have enough time to do an experiment because science is only 45 minutes long. It was a day to day thing. It was kinda hard to plan out. You tried to get in as many experiments as

> you could in that three-day period so that when it came time to move on in the reading section the next week, you wouldn't have the experiments to finish up. A lot of time we didn't get the full three days . . . so I might think of something to do next week but then our time would get cut short. . . . Even figuring out when to have a test was difficult. My teacher had a thing where they could never have a test on Monday because they haven't talked about it for two days. Tuesday, they get back late so you might have two sections to talk about, but you know you can't cover it in three days so you to extend it or slow down the pace.

Science in Sam's room was alternated with social studies, a common practice in primary grades. Sometimes it was done by unit and other times science was alternated daily with social studies and art. Sam said, "We can't do them [science and social studies] together in the same day. Not enough time. They are split up."

Tammy's schedule offered her the most exposure to science teaching of all the student teachers. Science was seldom cut from the day's schedule in a sixth-grade departmentalized setting where her cooperating teacher taught science for three periods in the afternoon. Each science period was 45 minutes long, and the schedule had to be maintained to ensure success of the departmentalized format. Tammy usually taught one or two of the science classes every day. Tammy felt that being able to teach science in this format helped her to refine the lesson by the end of the afternoon because she could identify concepts that students did not seem to understand during the first two classes and then she could either spend more time on them or use a different approach during the third class. Tammy tired of teaching science all afternoon by the end of the semester. She said, "I'd rather not teach the same thing three times in a row. . . . It's nice because it's three different classes, but it's also the same material three times so it does get repetitious."

Wendy and Rochelle had flexible schedules for science, a practice that both limited and enhanced Rochelle's exposure to science teaching. Rochelle's cooperating teacher used a flexible schedule for the content areas in the curriculum, working around the many other activities scheduled for her sixth-grade students. Many times, science was taught within integrated units or by the cooperating teacher's team partner. It was not taught every day unless it "fit into the schedule." This limited the time available for science teaching, and Rochelle did not receive the opportunity to teach science until the end of her student teaching. Rochelle utilized the flexibility in the schedule when she taught science. She felt free to take time away from other subjects if she needed to bring closure to a science lesson or to integrate science with math and social studies activities. Rochelle felt that science shouldn't be taught within a specified period of time. She did not want to rush a lesson in science if the students had more things to discuss. She reported, "I am not one for we have to do it [science] this certain amount of time. I allow time for questioning. As long as it takes. If we miss something that day, o.k. , we can pick it up the next day."

Similarly, Wendy did not have to be concerned about her cooperating teacher's schedule after she took over the responsibility for teaching the fifth grade. She was influenced only by her own scheduling of science. She taught science every day, fitting it where she thought it would work best, and working around the scheduling conflicts. Wendy saw her scheduling as a plus because she could allow as much time as she needed to complete a science activity. She often took the entire morning for integrated activities in science, math, and social studies relating to her geology unit and never stopped a lesson if the students were actively involved even if it took longer than she had planned.

Assertion #2 Student teachers develop their personal pedagogy as a result of their science teaching experience.

The elementary science curriculum was not familiar to the student teachers because of their limited teaching experience and paucity of memories of grade school science from their childhoods. Some student teachers found that teaching the science curriculum was a challenge to their personal knowledge and pedagogy skills. The student teachers had experienced cooperative group work with peers but had little or no experience using this technique with children, an impediment to their implementation of hands on activities from the curriculum. Strategies for teaching science were often chosen by student teachers based on the positive and negative responses of their students to their lessons and questions. Students tended to leave the student teaching experience less certain about how they would teach science in the future than when they began.

Sub-assertion 2A: The student teachers were surprised by the form and content of the science curriculum.

When student teachers entered their student teaching, they were not sure what was involved in teaching science in an elementary classroom. Was there a book they would have to follow? Would or could they make up science lessons to integrate with other areas of the curriculum? Most of them hoped to teach familiar topics. Angela wanted to teach about oceans. Rochelle was interested in space. Sam thought electricity would be fun to teach. None of them, as it turned out, taught a topic in their area of interest.

The science curriculum for the Pine School District is housed in kits that are checked out through the main office. Each kit is a complete unit and contains textbooks, materials to conduct some of the experiments in the student books, and some supplementary materials. Each teacher in the Pine School District was expected to teach four kits during the school year. Additional science supplies to complement the curriculum were available for checkout from the main office. Kits were distributed on a first come, first served basis, so teachers were not sure what topics they would be teaching if the requested kits were not available. Tammy wished that she could have taught a different topic from the animal kingdom, but that was the only kit available at the time her cooperating teacher called in her reservation. Tammy said,

> Just because I wasn't that familiar with the material on [body systems]. There are a lot of things that I truly don't know . . . deal with germs and diseases and all that stuff and how the red blood cells and white blood cells act.

Tammy could remember talking about the body system in the fourth and fifth grades. She commented, "It's not fresh in your mind and it's not easy to regurgitate everything you learned in sixth-grade terms. You can't say 'pancreas' and expect them to understand what it means."

The student teachers were surprised at the topics they were expected to teach in the science curriculum. They thought they would be able to teach about sound, water, air pressure, topics they had explored in their science methods class. They could recall very few memories of science from their own elementary years. Angela was probably the most surprised of all to learn she would be teaching cells and simple organisms in the sixth grade. She reported, "I did that kind of stuff when I was in biology in high school or college. It was 'Ooo, we are doing this again.' I remember in high school biology we had to learn all the different organelles and everything that they did. Even with the protists, I know at one time I probably learned about them, but I didn't remember much about them." She found that some of the material was new to her: "I remember learning about the parts of a cell and how plant cells and animal cells are different. . . . It was kinda like relearning it and then learning how to teach it to them."

The format of the district science curriculum confused the student teachers. They were not sure how to teach from it. Angela commented,

> The way the book is laid out, it's just really choppy. There will be like one paragraph on something and then there will be a little experiment to go with it. There will be two more paragraphs, but the next two deal with what you did in the experiments. So it's not like you could read one day about all the stuff, talk about it, and do an activity.

Sam didn't like the science book that came in the science kit on rocks, saying,

> The book wasn't that good. To me it wasn't very--it was just a fact here and a fact there. . . . It was just little paragraphs like maybe a paragraph on each page, and 400 pictures on each page . . so it wasn't very informative.

Tammy was trying to teach the systems of the human body and was surprised to find that the book didn't have much information on it. She said, "The book sums up the seven systems in, like, ten pages so they don't give much [information]. They don't tell and they don't prepare the teacher for the millions of questions that kids are going to ask." Wendy was adamant in her dislike of the curriculum after looking through two of the books during her first two weeks of student teaching. She commented,

> I would hate to follow that book. I am looking through it, going, "Yuk!" They were talking about properties of matter and it's going on about when you identify things, and they jumped right into fingerprinting. The correlation is so indirect.

Mary, who was teaching in the fourth grade, took an entirely different view of the curriculum. She liked the textbooks and thought they had a nice mixture of pictures, text and experiments. "I actually . . . I'm pretty much impressed with those books."

<u>Sub-assertion 2B: Student teachers interact differently with the science curriculum.</u>

The concept of teaching generally includes the concept of curriculum whose meaning is negotiated between teachers and students. For the student teachers, the Pine School District kits defined the curriculum, but they elected to use the kits differently in interpreting the curriculum to students. Mary followed the curriculum closely but adapted many of the activities to fit her style of teaching. She had the students read out of the book and used the information in it as a springboard for class discussions. She changed minor things in the experiments and the activities in the textbook, adapting them to fit into her lesson:

> Sometimes I do it as a [demonstration]. If I want it to be short, we will just do it in front of the class. I change them if I want to do it more with small groups instead of with a large class on some things.

She used ideas she found in the textbook to adapt activities. She said, "Some discussion questions gave me the idea to add the cold water to the fish . . . kinda the general outline of the experiment was there." She also used other resources to expand the material in the textbook, bringing laser disks, videos, other people, and experiments not found in the curriculum to class. She had each student squeeze a slice of bread to help them understand density and volume saying, "They talk about it there in the book. They say if you want to reinforce it, you can talk about bread. I thought I would actually have them smush it up and see, so."

Angela relied on the science textbook in teaching the curriculum. She admitted that she "followed the book" because it was so hard to plan out her lessons otherwise and because she was "afraid of the microscopic stuff." She liked to start out her lesson with an open ended question to find out what the students knew about the topic and then had the students read small sections from the book. She discussed the material with the class, often restating the information, and asked a mixture of open-ended and closed questions. She reviewed every day the facts and terms previously covered in the chapter. She reported, "We spent a lot of time reviewing science, more than anything else." She gave the students notes or outlined sections on the overhead to help them remember the terms. At the end of each chapter, Angela used teacher made games and activities to review the terms and the parts of simple organisms. She did some of the experiments from the book but other times skipped over them or read them to the class and had them guess the results. She said, "We just tried the experiments in the book. I think there might be more interesting experiments than the book showed." She had the students draw diagrams of every simple organism pictured in the book and label them. Angela adapted the test from the curriculum to include diagrams and terms she had emphasized throughout the unit.

Because she was co-teaching science with her cooperating teacher, Tammy modeled her teaching of the curriculum after her cooperating teacher. Tammy's basic strategy for science was reading the text and asking convergent questions to identify the key words and facts from the chapter. Every day, the terms were reviewed and new ones given by notes written on the board or overhead. She explained, "They took notes Monday, took notes today, and this is like really important things they need to know." Tammy added some of her own strategies when she taught. For example, she noted, "I like to use diagrams. Definitely! It is something that is concrete to them . . . a simulation of one part of the ocean. Cause you can't bring the ocean into the classroom." Other times she used drawings to give clues to information she wanted. She drew cows, bugs, and horses on her overhead notes as she was teaching the animal kingdom. Tammy added humor and exaggeration when she was reviewing or teaching the terms in an attempt to make it more interesting to the students. When she wanted them to give her the name of the soft bones in the body, she pointed to her nose and wriggled it. She told them "marsupial" was a fun word to say and exaggerated its pronunciation. Sometimes the students were assigned to read two or three pages from the book for the next day, and then the class lecture would focus on two or three questions about it that were written on the board. Other times, Tammy read to them orally or had students read. She commented, "Following along in the book while I read in the book seems real lame and boring but they all pay attention and they all follow along." Tammy sometimes added short activities to her lessons to help the students understand the concepts.

Wendy did not like the format of the curriculum and developed a unit based on the information in the textbook. Wendy felt that helping her students to "make the connection" and "get interested and enthusiastic about science" were more likely to happen if she modified the curriculum. She used the curriculum as a guide when she taught the unit on the changing earth. She picked out the main concepts and used them as her framework when she planned her own unit. She explained, "I kinda outlined what lessons I wanted to teach, what lessons would work, and what would help them out, and then I went back and did more details of what I want to do for this activity." She felt that many of the activities in the book did not make a connection to the concepts, so she looked at other resources to find different activities. Wendy said, "Some of them in the book were so indirect. I would have to go ahead and modify them, and I do some of them but not all of them." Wendy used a variety of different strategies as she taught the unit. To identify types of weathering, she brought in picture books of landforms and had the students bring in photographs of landforms they had visited. She made up her own worksheets to go along with the lessons she was teaching, saying, "The questions [from the book] were vague." Wendy felt that activities were important to making connections in science adding, "I always tried to get as many activities cause the book is so vague and it kinda skips and hops around. I went a lot slower than I expected." She tested more often than the required tests for the unit to find out if they understood the concepts she was teaching, adding, "I felt very comfortable with what they know."

Sam felt he hit "a big roadblock" in his science teaching when he got the district curriculum on rocks. He described his teaching from the curriculum: "It was more read this and do this. Let's try this activity and hope it works. I didn't have as many fun things to do with them like I wanted." Sam often read the textbook on rocks to the class and followed with questions about what he had just read and then repeated the information again. Sometimes, Sam had the students read orally and then repeated the information that was read. He tried to relate the pictures and information in the book to the students' lives either through questions or his own personal experiences. Sam used a few of the materials from the curriculum kit such as the magnifying glasses, the clay, and the sample rocks. Sam elected not to use the worksheets provided with the curriculum: "There were some [worksheets] with it, but I used other ones. Mrs. H said the worksheets aren't very well organized . . . difficult for the kids at the primary age." Sometimes, Sam did not finish the lessons he had planned to teach. He commented,

> I can't see just reading out of the book. I was having trouble reading out of those books in science cause I didn't know much about rocks anyway and I just felt kinda guilty with the kids just making them read some of the days. So I would say, "That's it! Let's go to . . . whatever."

Rochelle applied her philosophy that balance is needed in science teaching when she began to use the science curriculum on oceans. She explained, "Experimenting, reading, and answering some questions. It all goes together. We would read the textbook too, but it would go along with something we are doing." She did some reading out of the textbook when she first started teaching oceans since she had never taught the topic before. She moved into hands on experiments and activities after she had covered some of the concepts in the book. After reviewing the textbook, she decided to find other activities to use for reinforcing and expanding the concepts in the book. She located ideas in her college science methods notes, the Internet, and a packet of materials given to her by Mrs. G across the hall to use in teaching some of the concepts. She commented on how she could have made science teaching easier by following the curriculum but chose to do more activities, saying, "The easiest is the traditional, read out of the book and then discuss it. But the most enjoyable is like what I did with the whale and the penguin. That is the most enjoyable for me and the kids."

Sub-assertion 2C: Group management affects the efficiency of hands on science.

Group management skills can influence how student teachers choose to teach science curriculum. Sometimes student teachers were determined to use groups because they felt hands on activities should be part of their science teaching but found they struggled with group management. Management of groups during hands on science experiments and activities was an issue the student teachers talked about openly as they tried hands on activities in their classrooms. "Chaos" was the favorite term used to describe their first attempts to teach with cooperative groups.

Some student teachers developed some group management techniques in other subjects before using groups in science. Rochelle struggled with group management at the beginning of the semester when she took over math teaching. Her cooperating teacher used group work in several subjects, and Rochelle was able to learn some organizational skills for grouping children from her modeling. Rochelle finally came up with a plan that worked for her "social' group of sixth graders who had a hard time staying focused. She found that writing down the general steps to be followed by groups in organizing their activity was the key. Rochelle said, "Some people don't listen and other people don't get on task if you don't give them the tasks first." This technique informed the class what was expected of them in advance of science class. Rochelle also found that assigning students to prearranged science groups worked well for her. Mary had helped her cooperating teacher with group organization in the classroom before she tried it in science. Mary described her grouping technique:

> We put them in groups and give them each a number and they have to do different jobs. . . . Whenever I do groups, I do it that way, but I try to spread them out

> around the room. Sometimes . . . they say, "I don't want to do this task [the one assigned]" . . . sometimes I let them decide, figure it out.

Mary also learned that she had to set limits with the groups. She said,

> You can control to a certain extent, but you don't want it to be too controlled. Sometimes at that age they might want to get a little bit carried away. You want to set limits, but you don't want to limit them.

At first Mary was concerned about the noise level when the children worked in groups because she did not want her cooperating teacher to think the class was out of control. She felt differently after she was able to do a few lessons on her own: "I realize now . . . it is fine if they get excited."

Keeping students on task and working together in groups was difficult for some student teachers. Angela felt it was difficult to keep the students on task when they were working together. She reported, "Any opportunity they have to work with their friends, they jump at it. When we let them do that, there is probably one [group] that gets at the work. They talk." Rochelle found that she needed to assist the students in staying on task by moving around the room and talking with each group. She invited the groups to share their findings and ideas with each other as long as they stayed on task, expecting "structured, indoor noise" not "chaotic noise" that emanated from students off the topic. Mary found that although the students talked to each other in their groups, they often did not discuss their ideas about the experiment. She related, "Kids like to talk about other things in groups, but I think if you supply them with the fun, exciting things to do, I would hope they would stay on task." The students tended to work independently in the groups, writing down their own individual hypothesis, data, and conclusions. This resulted in some confusion when Mary wanted the whole group to share the data collected by the group. Mary worked on group communication skills with every science activity, trying different ways to help the students begin to share their ideas about the topic, but she also wanted the children to feel free to do some exploration on their own in addition to their directed assignment. Wendy found her class needed to learn group skills. She related, "How to work together effectively is probably what kids need to learn. If I give them a question to discuss . . . with someone else, they don't know how to do it."

Wendy wanted students to become actively involved in science and thought the group approach would help her attain this goal. She struggled with student behavior whenever she did group work. Since there were only nine students, she initially tried to break them into two groups--boys and girls. The girls did not get along well and "tried to outdo each other by playing around with the materials." Wendy tried different combinations for grouping but found the students had a hard time staying on task in any of them unless she sat down and worked directly with them. She tried stations, and that worked fairly well if she kept the students scattered around the room and gave them activity packets to complete at each station. Wendy moved away from group work when she found the students were not learning in that format.

Student teachers do not always feel comfortable using groups during science teaching but feel they should use them. Angela realized that small group work was a necessity for microscope work, especially after she encountered the confusion produced when the entire class gathered around an inadequate overhead microscope for an experiment with Euglena. She said, "It did work better when we had all the microscopes, but in most cases we probably couldn't continue to do that because it gets so out of hand." Angela experienced mixed emotions about letting students work in groups after she had used the microscopes. She reported,

> I felt like it was out of control but then at the same time I realized that it was probably good for them to just, you know . . . don't tell them what they are supposed to see . . . and then bring more order to it and find out what they did see.

Angela did bring group work into some of her paper-and-pencil orientated science activities but allowed very limited time for the groups to work together.

Sub-assertion 2D: Student response affects science teaching.

Some student teachers were more affirmed by student response to their lessons than others. Sam knew the students in his third grade classroom liked science, so he never seemed to be concerned with how they would respond to his lesson. He reported, "They were always, like, 'When are going to do science?'" Sam believed that science lessons should be varied so students would not have to be doing the same things every day. "If you just go straight through [the book], it just gets so repetitious and boring, I think, for the kids." Mary was more concerned about student responses to her lessons than Sam. She wanted the students to "have fun" during science class but also be learning. Every time they tried hands on activities, Mary wondered about the students' responses. She wondered how they would like the lobsters she arranged to have brought into the classroom and if they would learn from the experience. She reported, "It was fun. They enjoyed the lobsters so much. They learned so much. I could tell. They talked about it. They will say, 'I didn't know they could do this or that.'" Mary knew that she could not teach all her lessons with hands on activities so she wanted to find out how the students reacted to a discussion format that built on their experiences and prior knowledge. She related, "They just loved it [talking about the earthworms]. It was fun for them. I like it when the students go off and do stuff."

Wendy's biggest fear with all her lessons was that her students would think they were "dumb." Wendy was aware that her group did not react to science the way she had hoped they would. She felt that kids were afraid of science, saying, "I have a good portion of them that, if I give them any challenge, they shut down. They get frustrated with me and they start pouting." A common response during Wendy's discussions or demonstrations was "I don't get it." Whenever she heard that comment, she tried to adapt her lesson to help them make a connection with the concepts she was presenting. She welcomed student questions and used them to help the students make connections to the topic. Wendy also planned a backup lesson in case they didn't get it. She said, "Basically it's a worksheet that I give them to work on cause all it does is frustrate them and frustrate me [if it doesn't work]."

Some student teachers were influenced by evidences of student learning more than by their overall responses. Angela was excited about the students' learning from an assignment she gave on designing their own viruses and explaining how they worked in their bodies. Looking at their pictures, she explained, "I know just by putting cilia on your thing, they obviously know what cilia is. And you have the little mouth organelles. You know they understand it. All the kids seemed to go above and beyond." Angela talked about how she adapted her questions during a science lesson based on the students' responses to her science teaching approach, saying, "I usually ended up changing it in the middle of it, just because of what their responses were and things that I picked up that they were kinda interested in." It was important for Mary to find out if the students understood a concept that she was developing in her lessons. She said after the goldfish experiment,

> They talk as if they understood [about the difference in the goldfish breathing in warm and cold water] but I don't know. If I were to do it again, I would have taken more time and had them write something about it so that I could actually see the connection cause I had three people raise their hand and say, "Oh, I get it." But the other 17, do they get it or not?

The next day she followed through with a graphing activity on the goldfish experiment data to help the students see the relationship between the water temperature and the breathing rate of fish. When teaching about mass and volume, she realized that the students were confused and decided to stop her lesson and rethink her approach before going on. She said, "I think it is confusing . . . that mass is what something weighs—that is what weight is. Which one is heavier? We had never really talked about it so I didn't want to confuse them any more on which one is heavier or has more volume."

Tammy changed her teaching strategy based on student responses in each successive class she taught over the course of the afternoon. Sometimes she changed the questions she asked or decided a more visual approach was needed to help the students understand the concept. When she explained ocean currents, she drew a diagram on the board, reporting,

> I spent more time explaining what a current was to this [third] class. The other two classes were like "Huh?" When they hear it and they see it and any time you use more than one sense, I think you take in more than if I just stood up, and

> la,la,la . . . and some kids need the picture and some kids need to see all that, so I spent more time on this class . . . made sure they got it.

Another time when she realized that the classes were not getting the idea that blood can move at different rates through the circulatory systems, she added a simple activity for the last class. She had them take their pulses before and after running in place as a way to help them understand the concept. She also had them write a paragraph on what they noticed. She explained, "Some of them knew . . . your heart has to pump faster and all that stuff . . . but some of them . . . have not a clue." Lack of response to questions caused Tammy to try different ways to elicit the information she wanted. She said, "I always thought one kid somewhere in there would know the answer and it's not always true." When this happened, she used different strategies. Most of the time, she answered the question herself and then wrote down the information on the overhead for the class to copy. Other times, she gave various clues or broke the question down into smaller parts and tried to generate ideas from the students.

The student teachers in the study viewed questions posed by students during their science lessons in different ways. Sometimes, the students' questions motivated the student teachers to explore other ideas on the lesson topic or to try a different strategy to communicate a concept. Rochelle welcomed questions during her discussion and before, during, and after explorations. She used questions to facilitate further investigations, lead the students towards deeper thinking, and as a basis for adapting her lessons. Even such a simple question from the students as "Where are the ocean boxes?" prompted her to follow through with activities she had started earlier in her science unit. She was also influenced by questions that showed students were curious about topics related to the concept. When the students were investigating how whales keep warm in cold water, Rochelle's discussion deviated from the main concept when a student asked how long it would take the cold water to warm up if it were placed in the sunlight. He was curious because his group had come up with a hypothesis that whales might move towards warmer water to keep warm. She told his group to set up an investigation to find out. She said, "They surprised me. These ideas just popped up all over the place. I'm not going to rush it if they still have more things they want to get out."

Student teachers felt uncomfortable when students asked questions they were unsure of how to answer. Tammy was uncomfortable when students asked questions that were closely related to the topic but not really about what she was teaching. She commented, "There is always that kid that is going to ask you the hardest question, and you are never going to know the answer whether you try, try, try!" She told the students right from the beginning of the chapter she was teaching on the body systems that she didn't know the answers to all their questions, and they might have to look them up. Some days she invited questions and would try and answer the questions, and other days she ignored the questions.

Summary

The findings presented in this chapter indicated that this group of informants shared some common patterns as they tried to make meaning of science teaching during their student teaching experience. It presented the themes of (1) personal and professional career influences and (2) constant adjustments of teaching strategies. Assertions or statements about the theme were advanced and supporting evidence was given for each one. The two major assertions were (1) student teachers' views of science teaching are influenced by personal memories as well as by nonprofessional and professional mentors, and (2) student teachers develop their personal pedagogy as a result of their science teaching experiences. These assertions were then broken down into eight sub-assertions. The four sub-assertions of assertion one were personal images influence the act of teaching science, personal mentors can support science teaching, cooperating teachers have positive and negative influences on science teaching, and scheduling is one way cooperating teachers influence the teaching of science. The four sub-assertions of assertion two were the student teachers were surprised by the form and content of the science curriculum, student teachers interact differently with the science curriculum, group management affects the efficiency of hands on science, and student response affects science teaching.

CHAPTER VI

DISCUSSION, EDUCATIONAL IMPLICATIONS, AND RECOMMENDATIONS

Introduction

This study was motivated by my curiosity concerning science in the elementary school. Why and when do elementary teachers decide either to teach or avoid science in the classroom? After seeing the excitement and enthusiasm preservice teachers expressed about teaching science at the end of their science methods course, I began to speculate on why science was not taught more in elementary classrooms. Did their ideas about teaching science change during student teaching? Was student teaching a turning point for preservice teachers in their decision about whether or not to teach science actively in their classrooms?

The purpose of the study was to learn how preservice teachers make meaning of science teaching during their student teaching experience. My hope was to gain insight and understanding of science teaching during the student teaching experience by listening to and observing elementary student teachers as they taught science in classrooms. Six elementary student teachers participated in the study. All were participating in a 16-week student teaching assignment in a self-contained elementary classroom. The informants were five females and one male, ranging in age from 21-25. Three of the student teachers taught in sixth-grade classrooms and the other three taught at different grade levels, one each in third, fourth, and fifth grades.

Data were collected through interviews, observations of science teaching, and artifacts. Analyzing the data resulted in 27 codes which were later collapsed into five categories. Further analysis revealed two themes: personal and professional career influences and constant adjustment of teaching strategies. The six participants experienced these themes in various ways. Two assertions were made about the themes or patterns found in the study. They were (1) student teachers' views of science teaching are influenced by personal memories as well as by nonprofessional and professional mentors, and (2) student teachers develop their personal pedagogy as a result of their science teaching experience.

A review of literature related to the study is found in Chapter II. The rationale and procedures for data collection and analysis were described in Chapter III. Chapter IV contained portraits of the six elementary preservice teachers based on interviews and observations. Chapter V was used to report findings organized around the themes found in the study. This chapter contains conclusions of the study, implications from the study, and offers recommendations for further research.

Conclusions

In this study, I sought to learn how elementary preservice teachers made meaning of science teaching during student teaching. The conclusions of the study are based on information provided by preservice teachers and my observations of their science teaching and are illuminated in the section that follows by references to related literature cited in Chapter II.

Student teaching was the first time the study participants, with the exception of Rochelle, experienced teaching science to children. They were eager to try out some of the ideas they had learned in their science methods class and anticipated that science would be a "fun" subject to teach. They felt confident in their ability to teach science, consistent with the findings of Wenner's (1992) study of preservice teachers and their attitudes toward teaching science. This confidence about science teaching held by the student teachers changed as they encountered the reality of teaching science to children. By the end of their student teaching experiences, four of the six student teachers ranked science third or lower when asked to rank order the subjects they taught from most to least enjoyable. This ranking was consistent with the findings reported by West et al. (1993) on preservice teachers' subject rankings after completion of their student teaching.

The participants' experiences with science teaching were complicated by the many purposes served by the student teaching experience. Furlong and Maynard (1995) discerned that student teaching is a complex process in which student teachers move through five broad interrelated stages as they begin to gain control over their own teaching. Student teachers must not only go through the developmental process of becoming a teacher, they must also learn to teach all subjects in an elementary curriculum and mange a classroom. In addition, they must learn to work within the established norms of a cooperating teacher's classroom. Science teaching is just one part of the student teaching experience. Previous studies of science teaching by elementary student teachers (Abell & Roth 1992, 1994; MacDonald, 1994) each reported on the experiences of only one student teacher. This study provided a broader view of the complexities of science teaching within the context of elementary student teaching by studying the science experiences of six student teachers.

Most of the student teachers were placed in classrooms where the textbook was the base of science instruction, a practice consistent with Weiss's (1994) findings in her national survey of elementary schools, and science was not considered a core subject, similar to what Schoenberger and Russell (1986) found in their study of science teaching in elementary schools. Most of the student teachers in the study received little guidance for their science teaching from their cooperating teachers. None of the cooperating teachers were using inquiry-based teaching in science, although two of them used some hands on activities. Two of the cooperating teachers did not like to teach science. Some of the classroom environments to which the student teachers were assigned supported science approaches different from the established norms and others did not.

The breadth and depth of each student teacher's science teaching experience were affected by the scheduling of science by the cooperating teachers. Scheduling, as an element of teaching practice, has not been illuminated in previous literature, but this study found that it impacted the science teaching experiences of the student teachers. The cooperating teachers decide when and how long a student teacher will teach each subject area during student teaching. The student teachers in the study were not all assigned to teach science for the same amount of time. Three of them taught science for about eight weeks, Rochelle taught it for only three weeks, and Wendy and Tammy taught it for 12 weeks.

How and when science was scheduled in each classroom also played a role in the student teachers' science experiences. Some of them worked within an environment where science was scheduled for only three or four days of the week, placed as the last subject of the day, or cut from the schedule when time was needed for other activities. The student teachers in these environments had to choose strategies they felt would work within the time allotted for science. Others had flexible schedules that allowed them to integrate science with other subjects or take more time to develop a science concept. These students were able to try several strategies in their science teaching. One of the student teachers taught science in a departmentalized setting, giving her an entirely different experience in teaching science from the others. She experienced teaching science to three different groups of students every day, giving her the opportunity to adapt her lessons with each group. The rigid time schedule of three consecutive 45-minute periods and co-teaching with her cooperating teacher influenced her choice of strategies and her science experiences.

All of the student teachers initially indicated that they would like to try some hands on science activities, and all did try at least one hands on activity at some point in their student teaching. However, not all of them continued using this strategy. Three of the participants mixed hands on activities with other strategies throughout their student teaching. Two factors seemed to influence their decisions to pursue this approach.

Mentors who supported their efforts to use hands on activities in their science teaching were one factor. Two of the student teachers had significant people in their lives who encouraged them to try hands on strategies. Mentoring for another student teacher came from a cooperating teacher who encouraged her efforts at hands on activities through materials and resources. Karmos and Jacko (1977) found that student teachers sought support from both professional and personal mentors during their student teaching, but the literature did not reveal any studies on elementary student teachers seeking mentors in specific content areas. This study renders insight into how mentor support for science teaching can affect the science teaching experience of student teachers. A second factor for the three student teachers who found science mentors was their images of how they wanted to teach science in their classrooms. At the core of all their images was the belief that students should be actively involved in learning science. Many hands on strategies were tried by these three student teachers as they endeavored to implement their images. Although two of the three student teachers encountered obstacles that challenged their beliefs, they persisted in their efforts to make their images a reality. Without strong images or mentors, the other three student teachers adopted the images modeled for them by their cooperating teachers.

The literature on images revealed many studies on the general image of teaching held by preservice teachers (Johnson, 1992; Kettle & Sellars, 1996; Kuzmic, 1993) and the trials of implementing these images during student teaching (Calderhead & Robson, 1991; Johnson, 1994). The few studies on images of science teaching that exist have focused on inservice middle and high school teachers (Brickhouse & Bodner, 1992;

Tobin et al., 1990), but literature did not reveal any studies of images of science teaching held by preservice elementary teachers. Abell and Roth's (1994) study of one elementary student teacher referred to her image of science teaching, but it was not explored, nor were findings reported on this topic. This study provides findings on images of science teaching held by preservice elementary teachers and their attempts to implement them during student teaching. In addition, this study revealed how student teachers sought advice from mentors as they tried to implement their images, a phenomenon not addressed in previous literature.

Student teachers' personal knowledge about a science topic affected their science teaching experiences. Studies by Crawley and Arditzoglou (1988), Ginns and Watters (1995), and Wieseman and Smith (1997) found that preservice teachers hold misconceptions about the science phenomena they encounter, and their understandings of science concepts is often at the surface level. Three of the student teachers had to teach topics about which their content knowledge was limited. They relied on the textbook and limited student involvement in their lessons to keep student responses within their range of knowledge. This was consistent with findings by Dobey and Schafer (1984), Gee (1996), and Mellano (1997), who all found that teaching becomes factually orientated and hands on activities are not used when teachers are unfamiliar with the content. The student teachers who felt more comfortable teaching a science topic used more activities in their science teaching and brought more resources into their teaching.

Working with a science curriculum was a new experience for all the student teachers. Most of them found the format of the Pine School District science curriculum difficult to follow, so they emphasized what they felt was important for students to know. This confirms Cronin-Jones's (1991) findings that teachers pick and choose what they feel is important from a prescribed curriculum. Many of the student teachers emphasized the facts found in the textbook, while others followed the textbook and added other activities to make concepts more concrete to the students. In addition, many of the student teachers felt pressured to cover all the material in the chapter, a finding consistent with the findings of Shymansky et al.'s (1991).

The affective responses by students to chosen strategies was important to the student teachers in the study. This verified findings in Britzman's (1986) and Bullough's (1989) studies that preservice teachers envision successful teaching as nurturing, caring, and building relationships with students. The student teachers wanted their students to like what they did in science, selecting lessons and strategies that they hoped their students would think were "fun." Wendy worried before she taught any lesson about whether the students would think it was "dumb." Sam cut his lessons short if he thought he was boring his students. After every activity she tried, Mary's first thoughts were whether the students thought the activity was fun. Later, her concerns were related to student learning.

Many of the student teachers were still developing their classroom management skills when they took on science teaching. They were just beginning to feel confident in their ability to manage children in a large group setting. When most of the student teachers tried to implement hands on science activities using groups, they found it difficult to keep students on task and maintain control of the classroom. This influenced their decisions about using hands on activities in their classroom, corroborating the findings of Ellwein et al. (1990) and Borko et al. (1987) that preservice teachers found management of groups was necessary for successful teaching. Two of the student teachers were in classroom environments that used small group instruction, enabling them to develop skills in handling groups which carried over into their science teaching.

At the end of their student teaching experiences, some of the student teachers were not sure how they would teach science in their own classrooms. Angela realized during her student teaching that she was "afraid of science." She admitted to feeling more comfortable teaching science now that she had some experience, but she had no definite ideas about how she wanted to teach science in her own classroom. She felt the preparation time required for hands on activities might deter her from using them in the classroom. Sam had no idea how he would teach science in the future but had felt he should become "more knowledgeable," not having really done "much in science" during student teaching. Tammy's favorite word for science was "fun." She talked around the topic of how she would teach science in her classroom, saying "Oh, I might try experiments. I don't know . . . they need to have a textbook to have the facts. . . . It needs to be fun." During student teaching, she did not enjoy teaching things she did not know about or like. She had begun to realize that she knew more about science now that she had been "forced" to teach it.

Other student teachers knew how they wanted to teach science but had become more realistic about how to incorporate hands on science activities into their teaching. Mary planned to use a mixture of strategies in her science teaching. Helping kids make connections was important to her, and she knew that hands on activities would not always accomplish that. She knew that she might not do as many hands on activities in her classroom during her first year of teaching as she might later on because of the preparation time required for them. Rochelle thought her limited opportunity to teach science during student teaching had only reinforced her belief that science had to be hands on, minds on in her own classroom. Wendy still believed that science had to become "meaningful" to students. She wanted to use many hands on activities in her teaching but realized that she might need to simplify her approach, as she would not be able to spend as much time preparing for science as she had in student teaching. She also knew that she had to work on her classroom management skills if she wanted to make her image of science teaching a reality.

Implications

The findings and the conclusions from the study led me to think about how teacher education and the student teaching component within it may need to change to assist preservice elementary teachers in their journeys towards becoming teachers of science. This study suggested implications for practice beginning with the content preparation of preservice teachers and ending with what inservice teachers might do to make the journey easier and smoother for preservice teachers in the future.

Preparation in Content and Pedagogy

Teachers who are enthusiastic about science will usually teach science. Confidence and enthusiasm for science teaching need to be developed in preservice teachers. Knowing and understanding science content are important in the building of confidence and enthusiasm in science. Science content experiences other than the traditional lecture method of delivery need to be provided for preservice elementary teachers. Leaders of teacher preparation programs should redesign their science content preparation to include courses that develop science content knowledge while teaching pedagogical knowledge and/or skills. Science educators need to work with science colleagues to plan courses that model appropriate strategies for teaching specific science content and include practice in teaching science concepts.

More than one science methods course may be needed to prepare preservice elementary teachers for teaching science, especially if science content courses are taught in a traditional way. The science methods course is usually the first time that preservice teachers are formally exposed to science as a process. They need time to shift their science teaching paradigm and learn appropriate pedagogies for teaching science as a process. Science methods courses need to provide many science experiences for preservice teachers, both with peers and children, to help them assimilate science process skills into their prior conceptions of science teaching. This may be difficult to provide during one methods course.

Science methods courses must prepare preservice teachers for the curriculum used in elementary school classrooms. Preservice teachers need to work with the topics and content of elementary science textbooks. Content common to most elementary science curricula should be included in science methods courses to prepare preservice teachers for teaching the science in elementary schools. Preservice teachers assume they know many science concepts, found in elementary textbooks but often their understanding of them is superficial and incomplete. Before preservice teachers attempt to teach science concepts, they need to be able to describe scientific concepts and processes in simple terms and to apply the concepts to real-world situations. Preservice teachers also need to learn how to choose appropriate ideas and activities from other science resources and how to integrate them into a science curriculum.

Preservice teachers should also learn how to integrate the curricula of different subject areas to ensure that all subjects are taught within a school day. They should learn how to incorporate reading, math, and writing into science or science into other areas of the curriculum. Teacher educators should model integrated teaching and learning in the methods courses in teacher preparation programs and provide preservice teachers with practice in the application of integrated activities.

Teacher educators may need to consider designing activities for preservice teachers that challenge their existing beliefs about science teaching. Preservice teachers need to be exposed to analogies, exercises, and demonstrations that help them articulate their beliefs and learn how to transfer those beliefs into practice. Preservice teachers must learn to acknowledge the influences of their own schooling and the implications of their own thinking about good teaching practice and begin to negotiate new ways of thinking about science. Teacher educators could help preservice teachers articulate their beliefs and images of teaching by developing metaphors about teaching, asking students to compose autobiographies of previous school experiences, and using cases which show beginning teachers struggling to realize their beliefs in the classroom. Preexisting beliefs about science teaching should be elicited and challenged during the science methods course by including experiments that illustrate the limitations of many science teaching belief systems.

Pre-Student Teaching Field Experience

Field experiences should be a part of every science methods course. The chasm between the science methods course and student teaching needs to be bridged. Preservice elementary teachers need to apply their newly developed knowledge of science as inquiry in a supportive school setting before they do their student teaching. They need to plan science lessons and practice them with real students during a science field experience. The field experience should be structured in several short time frames within a semester to provide the opportunity for preservice teachers to have several experiences teaching science with small groups of children before teaching science to an entire class of children. Preservice teachers need to gain confidence in management skills, learn how to assess their own science teaching, and practice reflection during a science field experience.

Mentoring

Elementary student teachers need to be supported in their science teaching during the field experience and student teaching. Science educators should build networks of elementary teachers who are active teachers of science in the school districts where student teachers are placed. This group should design a support system for preservice students that will encourage them to use inquiry in their science teaching, locate resources for teaching science, and offer alternate strategies for science lessons. This group would need, also, to find science mentors for elementary student teachers when the cooperating teacher does not feel comfortable teaching science.

Student Teaching

Preservice teachers should be oriented to student teaching prior to their student teaching experience. They need to be prepared for the discrepancies that may exist between their expectations of student teaching and the reality of the classroom. Preservice teachers can predict some of the dilemmas and constraints they might face when entering an established classroom for a short period of time. They also need to understand how some of the conflicts and tensions in a student teaching setting can contribute to their practical knowledge of teaching.

Cooperating teachers should attend a seminar during semesters when they have student teachers. The seminar should include training in the various stages student teachers move through as they develop into teachers. This could help cooperating teachers to understand the roles they might need to take to facilitate each stage of development, providing the support necessary for the continual growth of student teachers into teachers. The seminars could also provide support for new cooperating teachers and explore, through discussion of transitioning theory to practice, new methods of teaching various subject areas. They could also bring the philosophy of the teacher education program and classroom practice of cooperating teachers into closer alignment through discussion of transitioning theory to practice.

To help facilitate effective communication about teaching, cooperating teachers should be carefully chosen and matched with student teachers. This could be accomplished by having cooperating teachers and student teachers write metaphors that describe themselves as teachers generally and how they view each subject area. The cooperating teacher and the student teacher would not have to have the same subject interests, but their philosophies of teaching and of children's learning should be matched.

Student teachers should be exposed to good modeling of teaching in as many subject areas in the elementary curriculum as possible. Elementary teachers usually do not view all subject areas in the curriculum equally. They seem to favor some subjects more than others and to be stronger teachers in their areas of interest. A dual assignment during their semester of student teaching could assure that student teachers spend time in environments that balance one another or are exposed to different ways of teaching. Student teachers could be placed in two separate classrooms with teachers who have different teaching styles and hold strengths in teaching different areas of the curriculum. This might ensure exposure to good modeling and positive teaching experiences in all content areas of the curriculum, including science, during student teaching.

Student teacher seminars should be structured to allow time for student teachers to meet in small discussion groups by grade level several times throughout the semester of student teaching. Each time they meet in the small groups, a different curriculum content area or management issue of interest to the group could be discussed. A university supervisor with knowledge in that area should be part of the discussion group. The university supervisor should facilitate the discussion and encourage the student teachers to share ideas and resources with each other but also offer suggestions and resources as needed. Student teachers and university supervisors should be encouraged to form support networks for sharing ideas in specific content areas.

Inservice Teachers

There is a need to think about inservice elementary teachers and their role as teachers of science. Teachers still cite, as they did 30 years ago, inadequate backgrounds in science and lack of time and materials as reasons for not devoting more time and effort to science teaching (Tilger, 1990). Inservice teachers need to take additional courses in science if the current state of science teaching in elementary schools is to change. Inservice training needs to move away from the one-time workshop approach to ongoing experiences that take place over a period of time. Training for inservice teachers may need to begin with developing familiarity with the content of elementary curricula currently in use and the understanding that science is more than a body of facts. It is a system for thinking about everything in the world around us. Inservice teachers should learn how to move away from using just the science textbook in their teaching by exploring other resources and teaching approaches, including hands on activities. Elementary inservice teachers need to participate in training on the national science standards (National Academy of Sciences, 1996) and be supported in their efforts to implement them into their teaching. Incentives may need to be a part of inservice programs to encourage inservice teachers to attend them. Support networks for encouraging the teaching of science among inservice teachers should also be developed.

Recommendations for Future Research

The results of this study reveal the need for ongoing discussion and research related to science teaching in the elementary classroom.

There are a number of ways this study could be replicated with one of the parameters changed. The participants in the present study were all in their early twenties. A similar study could be conducted using a mixture of older elementary education students and the traditional aged students to find out how the science experiences of the two groups might be similar and different. Elementary student teachers from a different teacher preparation program or in a different geographical location could also be studied to find out if their experiences were similar to those of participants in the present study. The study could be replicated with student teachers who had completed a field experience in science prior to their student teaching. Another way to alter this study would be to use as informants student teachers who were matched with cooperating teachers holding a similar philosophy of teaching science or with cooperating teachers holding different views of teaching science. All of these variations could provide information to assist science educators in designing future courses and programs and to aid student teacher placement services in developing useful placement practices.

A qualitative and quantitative study should be conducted on the perceptions of science teaching of elementary principals and the actual practice of science in their schools. Science instruction is not viewed the same in all elementary schools. What roles does the administrator of an elementary school play in the science instruction in an elementary school? Insight into why science is viewed as a low priority in elementary schools may come from this type of study.

A longitudinal study that follows a small group of elementary preservice teachers from student teaching through their first two years of teaching should be conducted to find out how their science teaching changes over time. The student teaching experience is just one step in the development of teachers of science. Knowing how elementary preservice teachers transition their science teaching from a controlled environment of student teaching to their own classroom can inform science educators in their planning of methods courses, support networks, and inservice training for early career teachers.

A qualitative study of elementary teachers who are actively using an inquiry-based approach to teaching science could be conducted to find out what led them to use this approach. Listening to the voices of inservice elementary teachers who use hands on activities and experiments in their science teaching would help inform science educators of factors underlying the decision to use this approach. Past awardees of the Presidential Award for Excellence in Science Teaching are a potential group for such a study, whose results could help in planning future professional development in science.

After a study has been conducted, ideas for further research often arise from the findings. This study uncovered many topics not previously reported in the literature that have potential for further study. Issues that lend themselves to further exploration are how science is scheduled in elementary schools, subject specific images held by preservice elementary teachers, the influence of subject specific mentors, the influence of personal mentors on student teachers, and elementary student teachers' reactions to and interactions with science curricula.

APPENDICES

APPENDIX A

PARTICIPANT LETTER

Dear participant,

Jackie Wilcox, a doctoral student in the Department of Teaching and Learning, College of EHD, is conducting a study on the science experiences of student teachers. Thank you for agreeing to be a participant in my dissertation study during the fall semester of 1997. I especially appreciate the fact that you are willing to give up some of your time during your student teaching experience. By agreeing to be part of a research study on the science teaching aspect of student teaching, you will be contributing knowledge and information to an area in education that has not been explored in much depth. It is hoped that this study will provide some understanding of how elementary student teachers make sense of science teaching which may aid in the planning of science methods courses in the future.

The purpose of the study is to gather information about science teaching in an elementary student teaching experience. The information will be gathered through interviews, journal writing or audio journals, artifacts from science methods experiences and lessons taught during student teaching perception of science teaching.

As a participant is this study, I invite you to enter into the following contract that specifies you involvement in the study.

RESEARCH CONTRACT

I hereby give my consent to participate in a dissertation study by Jackie Wilcox, a doctoral student at the University of North Dakota. I agree to be interviewed every two weeks during my student teaching experience and to be observed during my teaching of science lessons. I agree to write a science autobiography prior to beginning my student teaching and to share artifacts about my prior and present science teaching experiences. I will keep a reflective journal on the science lessons I teach during my student teaching experience.

I understand that all interviews will be taped and transcribed. A pseudonym will be used in all notes and in the written dissertation. My anonymity and the site of my student teaching assignment will be strictly protected in the written materials that result from the research. My participation in this study will have no bearing or relationship on my final grade for student teaching. I agree that my cooperating teacher can be interviewed after my final student teaching evaluation has been submitted to the university.

I have the right to terminate my participation in the project at any time. I am over the age of 18 and able to give informed consent. I understand that if I complete this study, I will receive a tool box science kit and a packet of science experiments to use with the materials include in it. I will also receive training by Jackie Wilcox on ways to use the science materials. If I have any questions, I understand I can contact Jackie Wilcox at 777-3155 or her advisor, Dean Mary Harris at 777=2675.

I have read this contract and agree with the conditions indicated.

____________________________ ____________________________

Participant Date

____

Jackie Wilcox

APPENDIX B

RESEARCH CONTRACT/COOPERATING TEACHERS

Jackie Wilcox, a doctoral student in the Department of Teaching and Learning, College of EHD, at the University of North Dakota will conduct a study on the science experiences of student teachers.

Thank you for allowing me to observe the student teacher in your classroom as part of my dissertation study on the science experiences of elementary student teachers. I need to observe the student teacher, who has agreed to be a participant in my study, during the actual science teaching to obtain a complete picture of his/her interactions with science and science teaching during this first experience in the public school. Throughout the course of the study, I will need to interact with you informally to increase my understanding of what is happening in the student teacher's science teaching. A formal interview, approximately 45 minutes in length, will be conducted with you after the student teacher's grade and recommendations have been turned into the university.

A pseudonym will be used for your name, the name of the school and the location of the school district in all notes and written material. You will be allowed to refuse to answer any questions during the interview or during an informal conversation. The interview with you will be taped and transcribed. Your anonymity will be strictly protected in my written materials.

I trust that observing in your class will not cause any disruption to your usual routine. I will make my presence as unobtrusive as possible. I will schedule my visits to the classroom to avoid conflict with any supervisory personnel assigned to the student teacher.

I will begin observing the student teacher in the classroom once he/she begins teaching science. I expect to be in the classroom only during the teaching of science lessons by the student teacher. If you have any questions concerning this study, you may contact me, Jackie Wilcox at 777-3155 or my advisor, Dean Mary Harris at 777-2675.

____________________________ ________________________

Researcher Date

I have read this contract and agree with the conditions indicated.

____________________________ ________________________

Cooperating Teacher Date

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